The National Assessment of Educational Progress (NAEP) Long-Term Trend Symposium

Background:

NAEP includes two national assessment programs—Long-Term Trend (LTT) NAEP and Main NAEP. While both assessments enable NAEP to measure student progress over time, there are similarities and differences between the two assessments. Both assessments measure reading and mathematics. The NAEP LLT assessment measures national educational performance in the United States at ages 9, 13 and 17. In contrast, the Main NAEP assessments focus on populations of students defined by grade, rather than age, and go beyond the national level to provide results at the state and district level. LTT trend lines date back to the early 1970s and Main NAEP trend lines start in the early 1990s. The content differs as well—for example, LTT math measures more "traditional" mathematics than the current Main NAEP math content.

The Main NAEP assessments in reading and mathematics are administered every two years, as required by law. The administration of NAEP LTT assessments in reading and mathematics at ages 9, 13, and 17 is also required by law, but the periodicity is not specified. The NAEP LTT assessments had been administered approximately every four years over the past two decades (and more frequently prior to that), but were last administered in 2012. The Governing Board postponed the NAEP LTT planned administration for 2016 to 2020, and then to 2024 due to budgetary constraints.

Main NAEP is transitioning to a digitally-based assessment. Given this and other issues, the Governing Board, in partnership with NCES, is gathering recommendations on how best to proceed with NAEP's LTT assessment and its relationship to main NAEP.

To inform any decision-making, the Governing Board has solicited five papers that identify issues to be addressed for the LTT assessment and consider its relationship to main NAEP. This symposium provides experts in the fields of assessment and education policy an opportunity to share their recommendations and to engage with Governing Board members and audience participants on how best to proceed.

To facilitate the discussion, Dr. Edward Haertel, the Jacks Family Professor of Education, Emeritus, at Stanford University, prepared a white paper on the history of the NAEP LTT assessment that includes a trenchant consideration of current issues. Speakers will discuss their responses to his paper.

Speakers:

Dr. Joe Willhoft (Moderator), Member, National Assessment Governing Board
Joe Willhoft is a consultant who recently worked for the Washington State Office of Superintendent of Public Instruction, both as the assistant superintendent for assessment and student information and as director of assessment. In addition, Dr. Willhoft served as executive director of the Smarter Balanced Assessment Consortium. He also led the research and evaluation department of Tacoma Public Schools for 15 years and served on numerous advisory committees and boards, including the Governing Board and the Council of Chief State School Officers. Dr. Willhoft holds a B.A. in Arts Education from Webster University, an M.A. in Special Education from American University, and a Ph.D. in Educational Measurement, Statistics and Evaluation from the University of Maryland.

Dr. Edward Haertel, *Jacks Family Professor of Education, Emeritus, Stanford University*
Edward Haertel has studied policy uses of achievement tests, validity arguments for high-stakes testing, the logic and implementation of standard-setting methods, trend comparisons across tests, and the use of value-added models for teacher evaluation. Over the course of his career, Dr. Haertel has served as president of the National Council on Measurement in Education (NCME), as a member of the National Assessment Governing Board, and as chair of the National Research Council's Board on Testing and Assessment. He is a fellow of the American Educational Research Association (AERA) and of the American Psychological Association (APA), and an elected member of the National Academy of Education. Dr. Haertel has received career awards from the NCME, Division D of the AERA, Division 15 of the APA and the California Educational Research Association. He holds a doctorate in measurement, evaluation and statistical analysis from the University of Chicago.

Jack Jennings, *Former President and CEO, Center on Education Policy*
Jack Jennings is the former president and CEO of the Center on Education Policy, a Washington, D.C.-based nonpartisan, nonprofit education research organization, which he founded in 1995. From 1967-94, Mr. Jennings served as subcommittee staff director and then as general counsel for the U.S. House of Representatives' Committee on Education and Labor. He is a member of the National Academy of Education and has served on the board of governors of the Phi Delta Kappa Foundation as well as on the boards of various other organizations. Mr. Jennings has received many awards, most recently from the American Educational Research Association, the Learning First Alliance and the National Superintendents Roundtable. In March 2015, Presidents, Congress, and the Public Schools, his latest book on school improvement and the federal role over fifty years, was released by the Harvard Education Press. Mr. Jennings's website is http://www.jackjenningsdc.com.

Dr. Lou Fabrizio, *Director of Data, Research and Federal Policy, North Carolina Department of Public Instruction*
Lou Fabrizio has been a member of the North Carolina Department of Public Instruction (NCDPI) for almost 24 years, working in different positions from 1978-81 and 1996-present. He was named the director of the Division of Data, Research and Federal Policy in August 2011 and is responsible for the management of the P-20W longitudinal data system federal grant, submission of several federal reports for the U.S. Department of Education, and understanding federal policy related to the Elementary and Secondary Education Act (ESEA) including the ESEA Flexibility (waiver) process and the more recent Every Student Succeeds Act (ESSA). From 2007-15, Dr. Fabrizio was a member of the National Assessment Governing Board. He currently serves as a member of the National Center for Education Statistics Advisory Task Force. He has been an active member of numerous other state and national committees and organizations, and previously worked in several different capacities for CTB/McGraw-Hill, the test publishing company, from 1982-96. Dr. Fabrizio holds a Bachelor of Science degree in physics from Georgetown University. He also has a Master of Science degree in education administration and supervision, and a doctorate in educational research and policy analysis from North Carolina State University.

Dr. Ina V.S. Mullis, *Professor, Educational Research, Measurement, and Evaluation, Boston College, and Executive Director, TIMSS & PIRLS International Study Center*
Ina V.S. Mullis is a renowned expert in large-scale educational assessment, first nationally and then internationally. She is a professor at Boston College, where she is the executive director of the Trends in International Mathematics and Science Study (TIMSS) and Progress in International Reading Literacy Study (PIRLS) International Study Center. Dr. Mullis played a leadership role in developing and reporting the results of the six TIMSS assessments, conducted every four years from 1995-2015 and the four PIRLS assessments, conducted every five years from 2001-16. Currently, Dr. Mullis is developing eTIMSS, an innovative digital assessment for 2019. Prior to joining Boston College in 1994, she was the project director of the National Assessment of Educational Progress (NAEP) at Educational Testing Service, and she serves on the NAEP Validation Studies Panel.

Dr. Andrew Kolstad, *Former Senior Technical Advisor and Psychometrician, Assessment Division, National Center for Education Statistics*
Until he retired in 2014, Andrew Kolstad was a federal civil servant working for the National Center for Education Statistics (NCES). He served as the senior technical advisor and psychometrician for NCES's Assessment Division, with oversight on technical issues for the National Assessment of Educational Progress (NAEP) and the National Assessments of Adult Literacy. Through his consulting firm, P20 Strategies, he does occasional work for the National Assessment Governing Board and for NAEP contractors such as Fulcrum IT and CRP, Inc. Dr. Kolstad has an intimate acquaintance with NAEP's methods and procedures, developed over nearly 25 years in NCES's Assessment Division as the senior technical advisor to the program. He has deep knowledge of the psychometric and statistical methods used in assessment surveys, such as NAEP, and understands how assessment surveys function. He also has expertise in both the psychometrics of educational testing and the statistics of inference from complex (stratified and clustered) surveys. Dr. Kolstad took the lead role in designing the 2004 bridge study for the NAEP LTT assessments. Dr. Kolstad earned a Bachelor of Arts in sociology from Columbia University, and both a Master of Science and a doctorate in sociology from Stanford University.

Dr. Peggy G. Carr, *Acting Commissioner, National Center for Education Statistics*
Since 2014, Peggy G. Carr has served as the acting commissioner of the National Center for Education Statistics (NCES) in the U.S. Department of Education. In this position, she oversees the collection, analysis, and reporting of education data from preschool through postsecondary education. Dr. Carr joined NCES in 1993 as director of analysis and reporting in the Assessment Division. In 1998, she was named the associate commissioner of assessment, responsible for national and international large-scale assessments, including NAEP, the National Assessment of Adult Literacy, the Program for the International Assessment of Adult Competencies, the Trends in International Mathematics and Science Study, the Progress in International Reading Literacy Study, the Program for International Student Assessment, and the Teaching and Learning International Survey.

Comparison of Long-Term Trend and Main NAEP

	Long-Term Trend Assessment	Main NAEP Assessment
Origin	Reading series began in 1971. Mathematics series began in 1973.	Reading series began in 1992. Mathematics series began in 1990.
Frequency	Since 2004, long-term trend NAEP has measured student performance in mathematics and reading every four years. Last reported for 2012, it will be reported next for 2024.	Main NAEP assessments measure student performance in mathematics and reading every two years.
Content Assessed	Long-term trend NAEP has remained relatively unchanged since 1990. In the 1970s and '80s, the assessments changed to reflect changes in curriculum in the nation's schools. Continuity of assessment content was sufficient not to require a break in trends. Mathematics focuses on numbers and numeration, variables and relationships, shape and size and position, measurement, and probability and statistics. Basic skills and recall of definitions are assessed. Reading features short narrative, expository, or document passages, and focuses on locating specific information, making inferences, and identifying the main idea of a passage. On average, passages are shorter in long-term trend reading than in main NAEP reading.	Main NAEP assessments change about every decade to reflect changes in curriculum in the nation’s schools; new frameworks reflect these changes. Continuity of assessment content was sufficient not to require a break in trends, except in grade 12 mathematics in 2005. Mathematics focuses on numbers, measurement, geometry, probability and statistics, and algebra. In addition to basic skills and recall of definitions, students are assessed on problem solving and reasoning in all topic areas. Reading features fiction, literary nonfiction, poetry, exposition, document, and procedural texts or pairs of texts, and focuses on identifying explicitly stated information, making complex inferences about themes, and comparing multiple texts on a variety of dimensions.

	Long-Term Trend Assessment	Main NAEP Assessment
Question formats	Students respond to questions in multiple-choice format; there are also a few short answer questions (scored on a two-point scale). In reading, there are also a few questions requiring an extended answer (usually scored on a five-point scale).	Students respond to questions of several possible types: multiple choice, short answer, and extended answer. Constructed-response questions may be scored as correct or incorrect, or they may be scored on a multi-level scale that awards partial credit.
Students Sampled	Students are selected by age (9, 13, and 17) to represent the nation and to provide results for student groups such as Black, Hispanic, White, and sometimes others, by gender, family income, school location, and school type (public or private). Students with disabilities (SD) and English language learner (ELL) students are included using the same participation guidelines and with the same accommodations (as needed) in main NAEP. Since 2004, accommodations have been provided to enable participation of more SD and ELL students.	Students are selected by grade (4, 8, and 12). Students represent the nation and provide results for student groups such as Black, Hispanic, White, and sometimes others, by gender, family income, and school location and school type. In some assessments, samples are chosen to report on states or selected large urban districts and as a result, more students must participate. The inclusion and accommodation treatment is the same for main and for long-term trend assessments.
Administration	Long-term trend is assessed every four years, throughout the school year: in October through December for 13-year-olds, January through March for 9-year-olds, and March through May for 17-year-olds. See the schedule for all assessments (long-term trend as well as main NAEP). Test booklets contain three 15-minute blocks of questions, plus one section of student questions concerning academic experiences and demographics.	Main NAEP mathematics and reading are assessed every two years (the odd-numbered years) at grades 4, 8, and 12. The administration takes place from late January through early March. Test booklets contain two 25-minute blocks, plus student questions concerning academic experiences and demographics. There may be ancillary materials provided with the test booklets.

	Long-Term Trend Assessment	Main NAEP Assessment
	There are no ancillary materials, such as calculators or manipulatives, provided.	
Results Reported	National-level performance and how it has changed since the 1970s is reported using scores on a 0-500 scale. Long-term trend also reports descriptive performance levels (150, 200, 250, 300, and 350) that have the same meaning across the three age levels. There are no achievement levels to correspond with those used in main NAEP. There are student questionnaires, but no teacher or school questionnaires.	Main NAEP has been reported since the 1990s for the nation and participating states and other jurisdictions, and since 2002 for selected urban districts. Performance and how it has changed over the past several years is reported using scale scores and achievement levels. Scores are reported using either a 0-300 or 0-500 scale, depending on the subject. The achievement levels reported are *Basic*, *Proficient*, and *Advanced.* Student results are reported in the context of the questionnaires given to the students' teachers and principals.

Future of NAEP Long-Term Trend Assessments[1]

A white paper prepared for the National Assessment Governing Board

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The National Assessment of Educational Progress (NAEP) encompasses several distinct assessments. In addition to its main series of periodic assessments at grades 4, 8, and 12 in various subject areas (main NAEP), these include the NAEP Long-Term Trend (LTT). The National Assessment Governing Board (Governing Board), created by Congress to formulate policy for NAEP, strives to minimize administrative and testing burdens entailed by NAEP data collections and to realize efficiencies in NAEP operations. Accordingly, the Governing Board's Strategic Vision calls for an examination of policy and technical implications related to the future of NAEP LTT assessments in reading and mathematics. A stakeholder outreach event, to be held early next year, will inform the Governing Board's deliberations as to whether LTT assessments should be continued independently from main NAEP assessments, whether it is feasible to blend LTT assessments with main NAEP assessments, and related questions. This white paper has been commissioned by the Governing Board in preparation for that event. It is intended as both a summary of the history of the LTT and an analysis of some options that the Governing Board and the National Center for Education Statistics (NCES) may wish to consider.

Introduction

The National Assessment of Educational Progress (NAEP) was conceived in the early 1960s as a new kind of assessment program, designed to describe and track the academic skills of United States citizens of school age and young adults. It was bold, innovative, and experimental. NAEP assessments were conducted beginning in 1969, but by the end of the 1970s, a decade later, some compromises had been made. The initial plan for NAEP had been scaled back considerably, some aspects of the original NAEP design had been reworked, and substantial further changes appeared unavoidable. Thus, around 1982, a Request for Proposals was issued for a new NAEP contractor, and under the new contractor, NAEP was redesigned and NAEP reporting scales were introduced for the first time. The first data collections under the new design occurred in 1984. The changes made in 1984 were so significant that it was not clear how, or even if, meaningful comparisons could be made between students' performance on the redesigned NAEP and the performance of earlier student cohorts on assessments dating back to NAEP's beginnings. In order to maintain comparability, NAEP continued with two parallel data collections. A scaled-back version of the original NAEP data collection design was continued, under the name "NAEP Long-Term Trend" (LTT). The new assessment design, data collection, analysis, and reporting came to be called the "main NAEP."

At the same time as the LTT tracked students' performance based on reading and mathematics learning objectives dating back to the 1970s, various aspects of main-NAEP assessments, including the subject area frameworks guiding main NAEP content, rapidly evolved. Around 1990, significant changes to the main-NAEP assessment frameworks for both reading and mathematics required that new score scales be

[1] This paper has benefited enormously from constructive comments and corrections by numerous reviewers. Their assistance is gratefully acknowledged. Any remaining errors are the responsibility of the author. Views and opinions expressed are the author's own and do not necessarily represent those of the U.S. Department of Education, the National Center for Education Statistics, or the National Assessment Governing Board.

created for main-NAEP reporting, so that today, the term "main NAEP" is used to refer to these NAEP assessments from 1990 to the present. At the same time, the LTT has preserved a capability for making direct comparisons of reading and mathematics assessment results from the earliest NAEP data collections (in 1970-71 for reading and 1972-73 for mathematics) up to and including the most recent LTT data collections in 2012.[2]

Thus, although main NAEP also provides information about achievement trends[3] over time, the main-NAEP trends extend back only as far as 1990 for mathematics[4] and 1992 for reading, and they are reported on different measurement scales from those still used for the LTT. Where they cover the same time periods, the LTT trend lines and the (shorter) trend lines from main NAEP do not quite match up (Beaton and Chromy, 2010).

At this point, the future of the LTT is unclear. LTT data collections planned for 2016 have been postponed twice, first to 2020 and then to 2024, primarily for budgetary reasons as NAEP has responded to other priorities.

The focus of this white paper is on the LTT assessments in reading and mathematics, as well as their relation to the main-NAEP assessments in these same subject areas. It is intended as a starting point for a broad discussion of the LTT assessments, offering an overview of issues and options that might be explored in greater depth in future papers and symposia. Specifically, this white paper offers a brief history of the LTT and then addresses the following questions:

- What are some arguments for and against continuing the LTT component of NAEP in essentially its current form versus dropping it altogether?
- How might the LTT component instead be integrated (or blended) with main-NAEP assessments?
- How might historical LTT data, main-NAEP data, and bridge study data be integrated to make NAEP more useful for longitudinal research?

History and Context of the Long-Term Trend Assessment

Planning for NAEP began when foundation support was secured in 1963 for an Exploratory Committee for the Assessment of Progress in Education (ECAPE), re-formed as the Committee for the Assessment of Progress in Education (CAPE) in 1968. In 1969, CAPE enacted a Memorandum of Understanding

[2] LTT trend lines were disrupted in 2004 when LTT data collection and analysis procedures were updated. Various changes to the LTT were made at that time, including new testing accommodation policies that brought the LTT into conformity with main-NAEP practices and with the requirements of the Individuals with Disabilities Education Act of 1990 and other legislation (see Olson and Goldstein, 1997). LTT trend lines were preserved by conducting two parallel sets of LTT data collections in 2003-04, one following prior procedures and the other following new procedures. Results from both versions, which differed by just a few points, were reported on the same scales, already established for the LTT. Those scales have been maintained for LTT assessments since 2004.

[3] Although the terminology of "trends over time" is commonly used and almost unavoidable, it must be remembered that each NAEP assessment is cross-sectional — no individual persons or schools are tracked over time. Thus, "trends" refer to comparisons of distinct groups, constituted from cohorts reaching specified age or grade levels in different years, such as 9-year-olds in 1971 versus 9-year-olds in 1975. In discussing assessment results, this report avoids referring to "changes over time" for the same reason, referring instead to comparisons of different cohorts over time.

[4] The grade 12 trend line in mathematics was disrupted in 2005, when two sets of results were reported.

(Resolution of Transfer) whereby the Education Commission of the States (ECS) assumed responsibility for NAEP governance. The ECS work was supported by an initial $1 million grant from the U.S. Office of Education (USOE), with further USOE support to follow. Thus, NAEP was born (Jones, 2004).

The assessment program envisioned by NAEP's founders looked very different from NAEP today. Originally, NAEP aspired to assess samples from the full populations of U.S. residents at ages 9, 13, and 17, as well as young adults. Ten subject areas were to be assessed.[5] As Jones (1996, p. 15) recounts, "The goals of NAEP were to report what the nation's citizens know and can do and then to monitor changes over time using objective-referenced assessment, a close kin to criterion-referenced assessment as had been proposed by Glaser and Klaus (1962) and by Glaser (1963)." Importantly, the original designers intended that "NAEP would assess knowledge and skills that could be gained from any source, not just from school learning. What citizens know can be measured; … how they acquired their knowledge would be far more resistant to discovery" (Jones, 1996, p. 15).

Lists of objectives in each subject area would be developed by a consensus process with broad representation of diverse points of view, and NAEP exercises[6] would be keyed to these objectives. There would be no such thing as a NAEP test score, or even a NAEP score scale. Instead, reporting would be in terms of estimated proportions of populations and subpopulations able to answer each exercise correctly. Some exercises would be released after each assessment, so that anyone could see examples of just what it was that respondents had been asked to do. Short-answer questions would be favored over multiple-choice. Some exercises would be given to small groups of examinees to solve together. NAEP samples would include children not in school, and these children would be tested individually, typically in out-of-school settings. No results would be reported for individuals, schools, school districts, or states, only for the nation and broad geographic regions (Northeast, Southeast, Midwest, and West); for broad demographic groups (defined by gender, ethnicity, level of parental education, degree of urbanization [size and type of community]); and for cross-classifications of such categories (Beaton and Johnson, 2004). This was a bold, radically new way of thinking about large-scale assessment, an experiment that had never been tried before on such a scale (Jones, 1996). The first NAEP assessments, in the areas of science, citizenship, and writing, took place in 1969-70. Reading was first assessed in 1970-71 and mathematics was first assessed in 1972-73 (Jones and Olkin, 2004, p. 562).[7]

The NAEP funding mechanism was changed from a grant to a contract in 1973. ECS continued to manage NAEP with USOE support until 1983, when ECS' final five-year continuation contract expired. Educational Testing Service (ETS) won the next NAEP contract, promising "A New Design for a New Era" (Messick, Beaton, and Lord, 1983), and assumed responsibility for NAEP in March 1983 (Jones, 2004). As discussed below, the ETS redesign did indeed bring major changes in NAEP's content specifications and exercises, as well as new procedures for NAEP sampling, administration, data analysis, and reporting. It would be a mistake, however, to imagine that NAEP prior to the transition from ECS to ETS was not already changing. Almost from NAEP's very beginning, it had proven necessary to modify one after another of its original guiding principles. Among other compromises, inclusion of children with severe disabilities proved prohibitively expensive. Contractors submitted fewer very easy items and a

[5] The original 10 subject areas were reading, writing, mathematics, science, literature, social studies, citizenship, art, music, and career and occupational development (Jones, 1996, p. 15).
[6] Items on NAEP assessments are sometimes referred to as "exercises," especially in older publications.
[7] For further detail, see also https://nces.ed.gov/nationsreportcard/about/assessmentsched.asp for a list of all NAEP assessments from 1969-70 to the present.

greater proportion of multiple-choice questions than had been specified. Within a few years, budgetary constraints forced discontinuation of testing for out-of-school 17-year-olds and of young adults (Jones, 1996), although 16- to 25-year-olds were assessed under a separate grant in a 1985 "Young Adult Literacy Study." Testing in areas relying most heavily on performance assessment, including art and music, also was judged too expensive to maintain. The content areas of reading and literature were combined into one in 1979-80.

Evolution of NAEP Objectives and Exercises Prior to 1983

In considering the future of the LTT, the question of what the early NAEP assessments actually measured is of some importance. NAEP exercises were keyed to NAEP objectives. Thus, it may be helpful to consider the early NAEP objectives in some detail.

ECS did not have the in-house capacity to develop objectives for all the content areas NAEP was to assess, and so it subcontracted with different organizations for objectives development in different areas (Lehmann, 2004). Moreover, to obtain different points of view, two or three separate contractors were engaged to work independently on objectives development for some areas. Thus, language arts objectives were drafted by ETS, reading objectives by Science Research Associates (SRA), and mathematics objectives by ETS, by SRA, and by the Psychological Corporation (PC). After objectives were submitted by subcontractors, a sometimes contentious process ensued, involving multiple reviews and revisions (Lehmann, 2004). Perhaps not surprisingly then, the organization of objectives differed from one subject area to another. Objectives were reviewed by lay panels as well as subject area specialists and measurement specialists. According to one knowledgeable pair of observers, however, the final result of this elaborate, broadly consultative process was that "National Assessment had not produced a set of new objectives … [but instead] its objectives represented a reorganization, restatement, and something of a summarization of objectives which frequently had appeared in print in the last quarter century" (Merwin and Womer, 1969, p. 316, as quoted by Lehmann, 2004, p. 65). It should be noted that although the exercises keyed to objectives were also carefully reviewed, apart from some tryouts to judge clarity of instructions and exercise difficulties, there was little or no pilot or field testing of exercises prior to live administration.

The objectives guiding the first (1972-73) NAEP mathematics assessment were published in 1970. There were 47 objectives for age 9, 45 for age 13, 78 for age 17, and 38 for young adults. For this first mathematics assessment, a three-dimensional scheme was specified for classifying objectives. The first dimension was "use of mathematics" (social mathematics, technical mathematics, academic mathematics, each with further subclassifications), but in the end, little use was made of this dimension, and it was dropped after the first assessment. The "objectives and abilities" dimension included "recall and/or recognition of definitions, facts and symbols," "perform mathematical manipulations," "understand mathematical concepts and processes," "solving mathematical problems — social, technical, and academic," "Using mathematics and mathematical reasoning to analyze problem situations, define problems, formulate hypotheses, make decisions, and verify results," and "appreciation and use of mathematics." These levels were reminiscent of the six broad levels of the Bloom Taxonomy (Bloom, Englehart, Furst, Hill, and Krathwohl, 1956), which were: knowledge, comprehension, application, analysis, synthesis, and evaluation. The "content" dimension listed 17 areas, including "attitude and interest." Today, almost a half-century later, some of the specific listed objectives seem quite dated, and others seem out of place in a mathematics assessment. Objectives for young adults included "use of computers," "keeping a checkbook," and "detecting flaws in advertising or propaganda arguments." One objective for 17-year-olds was "knowledge of scientific units, such as: calorie, B.T.U., foot-pound, ohm,

ampere, volt, watt, coulomb, erg, dyne, poundal, lumen, foot-candles, roentgen, angstrom, light-year, nail sizes, wire gauge, horsepower." The 17-year-old objectives also included "slide rule computation" and "explaining the long division algorithm in terms of successive subtractions," as well as "using nomographs," "finding square roots," and "computation with logarithms."

The first NAEP reading assessment was conducted in 1970-71, based on a list of objectives also published in 1970. Although the layout and organization of objectives for reading were quite different from those for mathematics, the reading objectives were also organized into broad categories reminiscent of the Bloom Taxonomy: "comprehend what is read," "analyze what is read," "use what is read," "reason logically from what is read," "make judgments concerning what is read," and "have attitudes about and an interest in reading." These categories were divided and subdivided into long lists of specifics. Within "comprehend what is read," for example, objectives included "read individual words," "read phrases, clauses, and sentences," and "read paragraphs, passages, and longer works." These in turn were divided into many subobjectives, each accompanied by lists of illustrative behaviors, down to such particulars as "interpret the sound patterns (intonations) suggested by punctuation marks" and "interpret intonation patterns such as tone of voice which are not completely represented in writing." Figures of speech to be comprehended included simile, metaphor, personification, hyperbole, litotes, metonymy, and synecdoche. The objective "obtain information efficiently" included as subobjectives "skim a paragraph or passage," "use the various parts of a book as aids in finding what is needed" (with parts such as title page, preface, index, and glossary listed by way of illustration), "find information efficiently in a variety of reference tools," and "obtain information from 'nontextual' sources." Illustrative behaviors included such specifics as use of the *Reader's Guide*, *International Index*, etc., as well as "libraries and card catalogs." As with the mathematics objectives, "recognize propaganda" was included, and another objective called for readers to "recognize the rhetorical techniques of the demagogue."

Objectives changed with each successive NAEP administration.[8] After the first mathematics assessment, roughly half the exercises were released. The remaining half were reused in 1977-78 to enable comparisons between student cohorts tested in 1972-73 versus 1977-78. Additional exercises for the second mathematics assessment were based on a streamlined set of objectives, dropping the "use of mathematics" dimension and using fewer, broader categories for the content and process dimensions. For "content," just five categories were used, down from 17 in the first assessment. These were "numbers and numeration," "variables and relationships," "shape, size, and position," "measurement," and "other topics." Just four "process" categories were used, down from six. These were "mathematical knowledge," "mathematical skill," "mathematical understanding," and "mathematical application." These changes were made in part with an eye toward grouping exercises in a way that would be meaningful for reporting NAEP findings. The second mathematics assessment also introduced student use of calculators on some exercises. Approximately one-third of the exercises from the second NAEP mathematics assessment were released, with the remaining (nonreleased) exercises again carried forward for reuse to measure differences in performance of student cohorts over time. For the third NAEP mathematics assessment, both content and process categories were again reworked, although changes were not as extensive as those from the first to the second mathematics assessments. Among other changes for the third mathematics assessment, "technology" was added as a content category and objectives addressing "estimation" ability also appeared.

[8] For mathematics, further information concerning changes to exercises and objectives from the first (1972-73) to the second (1977-78) to the third (1981-82) assessments is provided in NAEP Report No. 13-MA-10, *Mathematics Objectives: 1981-82 Assessment* (NAEP, 1981a).

After the first NAEP assessments of reading and literature as two separate areas in 1970-71, reading was assessed again in 1974-75, and reading and literature were combined and assessed as a single area in 1979-80, under a data collection design that also enabled separate reporting of achievement in reading. As with mathematics, roughly half of the reading exercises from the 1970-71 assessment were released, with the remainder kept nondisclosed for future use. The *Procedural Handbook* for the 1979-80 reading and literature assessment summarized the evolution of the reading objectives over prior assessments as follows:

> The first reading objectives were … [c]omprehensive in scope and very detailed, [and] addressed literary as well as nonliterary texts, [and] literary terms and skills as well as terms and skills more closely associated with reading instruction … In contrast, the second reading objectives … were much less detailed and concentrated solely upon the goals of reading instruction defined quite narrowly. Consultants felt that reading should be differentiated from literature since each was a separate assessment area and a separate instructional field in the schools. The second objectives were also somewhat more behaviorally oriented and more directly tied to what might be measurable.
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> The first [1970-71] literature objectives … stressed knowledge of classic works, skills necessary for interpreting works and activities that promote involvement with literary experience. They ignored skills involved in learning to read. The objectives developed for the 1975-76 literature assessment (which, for financial reasons, never took place) were quite different. Rejecting the notions that "literature of excellence" could be defined or that acquaintance with classics could be assessed meaningfully, the consultants placed more emphasis on response and valuing. Instead of defining literature as "great books," they defined it as "language used imaginatively" and created objectives designed to determine how much exposure students have had to imaginative language in a number of social and academic contexts. Again, the objectives made no mention of reading skills per se. (NAEP, 1981b, pp. 1, 4)

The 1970-71 reading objectives, the 1974-75 reading objectives, the 1970-71 literature objectives, and the 1975-76 literature objectives all informed the development of reading and literature objectives for the 1979-80 reading and literature assessment. For that assessment, objectives were organized into four areas: "values reading and literature," "comprehends written works," "responds to written works," and "applies study skills in reading." After considerable discussion, it was concluded that word attack skills would be omitted. Reading rate, skimming, and scanning were assessed "in a limited way" as part of study skills (NAEP, 1981b, p. 5).

The 1981-82 NAEP mathematics objectives and the 1979-80 NAEP reading objectives have continued to define the content of LTT assessments in these respective subject areas. Thus, they remain highly relevant to the problem of describing the domains of knowledge and skills addressed by these assessments. This topic is addressed in greater detail at the end of this discussion of history and context, in a subsection titled "What do the LTT assessments measure?"

Evolution of NAEP Reporting Prior to 1983

As already noted, early NAEP measurement targets were akin to observable attributes, as opposed to underlying (latent) attributes (constructs) accounting for observed regularities in performance (cf. Kane, 2006, p. 32). This objectives-based vision comported well with the language and logic of behavioral

objectives and promised a direct, immediate form of interpretability via actual exercises together with information about respondents' success rates. In accordance with this vision, the original model for reporting NAEP results was to provide proportions correct for individual exercises together with publication (release) of a subset of those exercises. Lee J. Cronbach, one of the original ECAPE (later CAPE) members, recalled in a 2004 interview that:

> First, … there was interest in making the results comprehensible to teachers in terms that they could put to use in their teaching. Second, the reports to the public were to be as free as possible from measurement technology … The idea of scores was dismissed pretty much outright. … In the end, we thought we could establish something a bit like opinion polling … [with] newspaper releases and have columns in which they laid out the questions and the data that came back. … [T]he idea was to directly report the exercises together with the percentages correct. It might have been presented first for all students, and then for whatever subgroups were to be identified. (Cronbach, 2004, pp. 141-142)

Unfortunately, this reporting model proved awkward and ultimately unworkable for two reasons. First, reports of proportions correct for hundreds of separate exercises proved difficult to comprehend and summarize. Second, exercise-level reporting absent any kind of item calibration made it difficult to compare successive cohorts over time. To address the first of these concerns, shortly after the first NAEP assessments, exercise-level reporting was supplemented with reports of average performance for groups of exercises, often sets of exercises keyed to the same objective or a group of related objectives.[9] However, reports of average percentages correct for groups of exercises also had serious limitations. Because the exercises released after each assessment were not reused, new exercises had to be added after each assessment to replenish the pool. Adding exercises meant that the set of exercises keyed to a given objective was shifting over time, and so average performance one year, across one set of exercises keyed to a given objective, was difficult to compare with average performance for some other year, across a different set of exercises keyed to that same objective (Beaton and Johnson, 2004; Jones, 1996). Note also that, while individual exercises could each provide a series of data points over the assessments for which they were used, as soon as an exercise was released, its particular series of data points was terminated, because released items were never again used. The dwindling pool of secure exercises dating back to the earliest assessments was one of the major problems prompting calls for a new NAEP design in the early 1980s.

Cronbach went on to recall that:

> The only statistic that was of great interest to us was the standard error and the percentage correct on each item in turn. Well, the whole point, you see, was to get away from reports about "people are proficient," "people are meeting the national objectives," or whatever. … Our position from the beginning was that we were going to offer minimally processed reports on what was observed in student performance. We did not expect any user to need technical understanding to deal with the reports. Obviously, we had this terrible high-bandwidth reporting scheme that collapsed of its own weight. Nobody took it seriously. But this was still the basis for deciding that an assessment exercise was satisfactory. (Cronbach, 2004, pp. 147-148)

[9] Exercise-level proportions correct were still included in appendices to NAEP reports.

In a paper commissioned for the 20th anniversary of the Governing Board, Lawrence C. Stedman recounted the ECS plan for "minimally processed reports," which in some ways followed the earlier ECAPE/CAPE vision:

> In 1970, ECS explained that it would "issue National Assessment reports from time to time without interpreting the results or explaining their implications" ... Instead, ECS routinely asked subject matter professional associations … to independently write interpretive commentaries ... Early NAEP reports were often written by panelists (sic) of leading math, social studies, or literacy educators and included quotes and observations from them about the diverse meanings of the findings ... Many perspectives were heard. (Stedman, 2009, p. 36)

Given such an unwieldy reporting scheme for even a single assessment, it is perhaps unsurprising that apparently little or no attention was devoted to the problem of describing changes across two or more assessments. As Cronbach (2004, p. 153) lamented, "You can collect information on a tremendous number of items. But when you try to aggregate items and say these items all require [for example,] understanding of measurement principles, that is so remote from the subtle item itself that most of the information is getting lost because the different questions will have different meanings. … But you can't run an assessment at that fine grain."

1983 NAEP Redesign

In March 1983, ETS took over the management of NAEP from ECS, promising "A New Design for a New Era" (Messick, Beaton, and Lord, 1983). The major conceptual shift in the NAEP redesign was a move from objectives-referenced to construct-referenced assessment. Under the original vision for NAEP, each particular exercise had its own story to tell. Under the new design, exercises were interchangeable indicators of examinees' standing with respect to underlying traits or constructs. In retrospect, this shift was probably inevitable. It was in one way an advance because by the 1980s, the influence of behaviorist psychology was waning. The conception of educational goals in terms of behavioral objectives, epitomized by the Bloom Taxonomy published in 1956, was also giving way to conceptions framed by the cognitive psychology of school subjects, with construct-based theorizing about the structure of knowledge in long-term memory, the relation of new knowledge to what was already known, and metacognition. It was in another way a retreat, however, because the move from objectives-based to construct-based assessment made NAEP much more like a conventional test, measuring just a few broad constructs and inviting primarily norm-referenced — not criterion-referenced — interpretations, albeit at the level of populations, not individuals. The description of populations in terms of score distributions, even multivariate distributions across some small number of constructs, seemed impoverished relative to the rich portrait promised by information about performance across hundreds of specific exercises keyed to dozens of specific learning objectives.

Item Response Theory (IRT) was at the heart of a new, sophisticated, and state-of-the art data analysis plan used to create reporting scales (NAEP scale scores) for each subject area and to estimate scale score distributions for various populations and subpopulations. Creation and use of scale scores solved some serious problems that the original NAEP design had faced, including the problem of maintaining comparability over time while refreshing the exercise pool.

IRT also promised to help offset the loss of criterion-referenced information about performance on individual exercises, offering instead a new form of criterion-referencing whereby released exercises could be pegged to particular scale scores to illustrate what kinds of things students at different score

levels knew or were able to do (Beaton and Allen, 1992).[10] In addition to illustrating points along NAEP scales with individual items, more general descriptions of scale score regions were also created. For this purpose, a set of "performance levels" was chosen, equally spaced along a NAEP score scale. Next, sets of exercises were identified that, by and large, students at each specified performance level could answer correctly but those at the next lower performance level could not. Finally, content experts reviewed these sets of exercises and wrote descriptions of the knowledge and skills that students at each performance level could demonstrate.[11]

The ETS scaling model for NAEP relied on data collections following a "balanced incomplete block" design, with exercise booklets "spiraled" (the BIB-spiral design). That meant that exercises were first assembled into blocks, and two or three blocks of exercises were then assembled into booklets, in such a way that different combinations and orderings of blocks appeared together in different booklets. Each exercise block appeared in all possible positions (beginning, middle, or end) in one booklet or another, and all possible pairs of blocks appeared together in at least one booklet, but not all possible block combinations and orderings were used. Thus, this was an "incomplete" block design. The different booklets were then "spiraled," meaning that they were assembled (physically stacked) in rotation starting at different points in a sequence, so that when booklets were distributed within a single classroom, dealt off the top of the pile, nearly equal numbers of children within each testing session would receive each possible test form. This highly structured data collection design was intended to assure that every test item and every pair of test items would be administered to randomly equivalent subsamples of students — nearly the same numbers of students and the same types of students for every subsample — so that intercorrelations between all possible pairs of items could be calculated.

NAEP's transition to IRT scaling did not go smoothly (Mislevy, 1987). Beaton, writing about the analysis of 1983-84 reading data, summarized some of the difficulties:

> The development of the reading scale required some improvisation. The ETS proposal assumed that a block of reading items would include about twelve scalable reading exercises which would span a wide range of difficulty so that few students would be able to answer either none or all of the exercises correctly. Because many students would be given two or three reading blocks, there would be a large, random, subsample of students who responded to around 24 items. Twenty-four items is approximately the number of exercises usually suggested for estimating individual performance using the maximum likelihood method. However, we did not know all of the properties of the reading exercises at the time of proposal writing and, within the transition time constraint, we were not able to form blocks of exercises that met the "twelve exercises to a block with varying difficulty" criterion. Some of the blocks had fewer exercises, some students did not respond to all the exercises offered, many students were able to answer all exercises correctly, and many others scored less well than would be expected by chance. The total effect of these factors was that maximum likelihood estimates of reading proficiency were attainable for only a non-random subsample of NAEP students. (Beaton, 1987, p. 230)

[10] See also http://nces.ed.gov/nationsreportcard/ltt/performance-levels.aspx.

[11] These performance levels are not to be confused with main-NAEP achievement levels (*Basic, Proficient,* and *Advanced*). Achievement levels, established by a different process to define goals and expectations for student achievement, are important in the reporting and interpretation of main-NAEP assessment results. They are defined only for main-NAEP assessments and have never been established for LTT assessments. The earlier performance levels can still be used as an aid to interpreting results from LTT assessments.

Thus, the original analysis plan, which envisioned joint estimation of person and item parameters using LOGIST,[12] was abandoned. Mislevy (1985), recognizing that there was actually no need to estimate individual students' scores, took the lead in formulating a marginal maximum likelihood (MML) analysis strategy using BILOG (Mislevy and Stocking, 1989), with conditioning to "borrow strength" across responses from multiple examinees and to avoid bias in parameter estimates for subgroups. The new analysis strategy also required multiple imputation (i.e., sampling of "plausible values" from posterior distributions of ability for each examinee) to enable accurate estimation of population variances and of precision (Beaton, 1987). These procedures, initially presented in ETS technical reports, were more fully documented in subsequent publications (e.g., Mislevy, 1991; Mislevy, Beaton, Kaplan, and Sheehan, 1992; Mislevy, Johnson, and Muraki, 1992).

At the same time that ETS confronted the challenges of shaping NAEP's future, it also confronted challenges from NAEP's past. As the new NAEP contractor, ETS was committed to maintaining links to earlier NAEP administrations.[13] What ETS staff had to work with were raw data files and reports from administrations of objectives-based pools of exercises that had been written and assembled with little or no pilot or field testing and with no attention to questions of dimensionality (Cronbach, 2004; Lehmann, 2004; Johnson, 1988; Mislevy and Sheehan, 1987). Moreover, during previous NAEP data collections in some subjects, tape recordings of instructions and exercises had been used to guide students through the testing session. Students were expected to listen to the tape and follow along with the identical text in their exercise booklets. This procedure, referred to as audio-paced tape administration, was intended to assure that students did not spend too much time on any one exercise, had time to attempt all the exercises in the booklet, and were not unduly penalized for possible reading difficulties that were irrelevant to the content being assessed. However, a consequence of paced tape administration was that all students in a given testing session had to be given the same test form. Thus, under that original NAEP data collection design, referred to as "multiple matrix sampling," there was almost no overlap among exercises in separate booklets, and so the earlier NAEP data largely took the form of separate, nonoverlapping sets of exercises administered to distinct (although arguably randomly equivalent) samples of students.

Linkage to earlier assessments was accomplished via IRT, but again, some compromises were necessary. These analyses are described in detail in NAEP technical reports for reading (Mislevy and Sheehan, 1987) and mathematics (Johnson, 1988). For mathematics, IRT scaling extended only as far back as the second mathematics assessment, in 1977-78. By fitting lines to logit-transformed percents correct (p-values) for exercises administered in both 1972-73 and 1977-78 at each age level, the IRT-based scales were then extrapolated back to the first mathematics assessment. In addition, for both subject areas, only a subset of exercises could be used. This means that the NAEP LTT scales created at that time may not have been

[12] LOGIST and BILOG are two early computer programs for IRT estimation. For a detailed comparison of the two, see Mislevy and Stocking (1989).

[13] Initially, LTT trend lines were established for the areas of science, reading, mathematics, citizenship/social studies, and writing. For citizenship/social studies, one assessment prior to the redesign, in 1975-76, was linked to ETS-fielded NAEP assessments in citizenship/social studies (1981-82) and civics (1988), at which point this trend line ended. For writing, the 1969-70 assessment could not be linked successfully to the second assessment in 1984, and so the reported LTT trend in writing began with 1984 and ended with 1996 assessments (Jones and Olkin, 2004, pp. 562-563). The LTT trend in science continued until 1999. After careful consideration, the Governing Board chose not to include science in the next LTT assessment, in 2004, because item content was seriously out of date and it was unclear how comparable replacement content could be created (Governing Board, 2002; Stedman, 2009, p. 6). Thus, the focus of this white paper is solely on the LTTs in reading and in mathematics.

fully representative of the 1981-82 mathematics and 1979-80 reading objectives. A thorough analysis of relationships among the objectives, the full ECS item pools, and the item subsets actually scaled would help to inform the question of which domains of knowledge and skills the LTT assessments actually address, as discussed later in this paper.

To maintain trend lines, ETS administered two separate assessments. BIB-spiraling was introduced for the larger data collection, which was referred to as "main NAEP." The smaller data collection replicated earlier, audio-paced tape administration procedures with multiple matrix sampling, initiating what came to be called the NAEP Long-Term Trend component. LTT assessments followed the previous ECS administration schedule, with 13-year-olds assessed in the fall, 9-year-olds in the winter, and 17-year-olds in the spring. The first separate NAEP and LTT assessments under ETS occurred in reading in 1984 (1983-84 for the LTT) and in mathematics in 1986 (1985-86 for the LTT). This split is depicted schematically in Figure 1 by the bifurcation of one horizontal line into two, in 1984 for reading and in 1986 for mathematics. The figure offers a graphical representation of the dates of main-NAEP and LTT assessments. Assessments linked together as part of a common trend line are connected by horizontal lines, as are future assessments for which such linkages are anticipated. Places where trend lines have been affected by procedural changes are signaled by shifts from dashed to solid lines.

View Figure 1: Timelines for Long-Term Trend (LTT) and Main NAEP, showing past and future anticipated trend line changes. [Page 43]

Note that prior to 1990, the term "main NAEP" was used to refer to the larger, BIB-spiraled NAEP data collections in 1984, 1986, and 1988, in contrast to the "Long-Term Trend." Since 1990, however, the term "main NAEP" as applied to reading and mathematics assessments has been used almost exclusively to refer to data collections based on revised reading and mathematics frameworks introduced in 1990 and 1992, as discussed later in this paper. For the sake of clarity, therefore, the "main NAEP" assessments during the 1980s are referred to as "pre-1990 main NAEP" in the remainder of this paper.

NAEP and the LTT From 1986 to 1990

Pre-1990 main-NAEP and LTT assessments in both reading and mathematics were conducted by ETS for a second time in 1986. Further problems arose in 1986 in the pre-1990 main-NAEP reading assessment. The estimated performance of 17-year-olds declined sharply from 1984 to 1986, a drop so drastic that it was not credible (Beaton and Zwick, 1990). Performance of 9-year-olds also fell, although by a lesser amount, and performance of 13-year-olds increased slightly (Zwick, 1992b). This was the "NAEP reading anomaly," which led to a decision not to report any NAEP reading results for 1986. The reasons for these anomalous results may never be fully understood, but much of the problem was attributed to failures to account for changes in the locations where exercises appeared within booklets, as well as interactions among exercises (context effects). The reading anomaly was a wake-up call: Items (exercises) could not be treated as statistically independent indicators of achievement that would function in the same way regardless of context. IRT could not be relied on to produce comparable estimates unless care was taken to minimize changes to the administration contexts of individual exercises (e.g., antecedent exercises, placement within the overall testing session).

Numerous further changes were made over time. Pre-1990 main-NAEP assessments sometimes sampled both age- and grade-based student populations. Assessments were conducted at grades 4, 8, and 12 in 1984; then 3, 7, and 11 in 1986; and then 4, 8, and 12 in 1988 and thereafter. Age groups were defined by

birth dates between October 1 and September 30 for 17-year-olds and between January 1 and December 31 for 9-year-olds and 13-year-olds. NAEP under ECS had used separate testing windows for 9-, 13-, and 17-year-olds spaced throughout the school year. For main NAEP, these were shifted to a common testing window.[14] Sources of information for identifying students according to race/ethnicity changed. The subcontractor for NAEP sampling changed from Research Triangle Institute (RTI) to Westat, after which procedures for post-stratification adjustments were modified slightly. Technical improvements were also introduced, including use of the Partial Credit Model (Masters, 1982) for IRT calibration of some exercises and conditioning on principal components of background variables instead of the original variables themselves.

In addition, the plan set forth in the ETS proposal had called for BIB-spiral designs in which exercise blocks from two or more subject areas would appear together in some exercise booklets, enabling the estimation of student-level correlations among scores across subject areas. Unfortunately, even with the new MML/multiple imputation analytical strategy, assessing individual students in more than one subject area reduced the number of exercises administered within a single subject area to a level that was suboptimal. Thus, the originally proposed BIB design was replaced in 1988 with a "focused BIB" design, in which individual students were assessed in only a single content area (Beaton, 1990b).

Age-based versus grade-based populations are not directly comparable, which is one reason why NAEP reports are deliberately structured so as to discourage direct comparison between main-NAEP and LTT trend lines.[15] Thus, trend reports and cross-sectional reports generally appeared in separate publications. Nonetheless, up through the 1988 assessments, there was just one NAEP scale for reading and one for mathematics.[16] *The Reading Report Card, 1971-88: Trends From the Nation's Report Card* (Mullis and Jenkins, 1990) reports only a single trend line for each age/demographic group, with no differentiation between pre-1990 main-NAEP and long-term trends. Likewise, *The Mathematics Report Card: Are We Measuring Up? Trends in Achievement Based on the 1986 National Assessment* (Dossey, Mullis, Lindquist, and Chambers, 1988) reports only single trend lines, again with no differentiation between pre-1990 main-NAEP and long-term trends.

Main NAEP and the LTT From 1990 to 2012

Beginning around 1990, the NAEP governance structure changed significantly. As part of the 1988 reauthorization of the Elementary and Secondary Education Act of 1965 (P.L. 100–297, the Augustus F. Hawkins-Robert T. Stafford Elementary and Secondary School Improvement Amendments of 1988), Congress created the independent, nonpartisan National Assessment Governing Board (Governing Board). Although the National Assessment was placed within the National Center for Education Statistics (NCES) under the supervision of the Commissioner of Education Statistics, the Governing Board was given responsibility for formulating policy guidelines for the National Assessment, selecting subject areas to be assessed, developing assessment objectives and test specifications, and other matters. Notably, the Governing Board was also given the responsibility to "identify feasible achievement goals for each age and grade in each subject area to be tested under the National Assessment." In response to this mandate to

[14] These changes over time for main NAEP are detailed on the NCES website. See https://nces.ed.gov/nationsreportcard/tdw/overview.

[15] One of the few published direct comparisons of main-NAEP versus LTT trend lines was reported by Beaton and Chromy (2010), under the auspices of the NAEP Validity Studies Panel. See also Pellegrino, Jones, and Mitchell (1999, pp. 73-77).

[16] Discussion of separate IRT calibrations for subscales within each subject area is beyond the scope of this paper.

develop achievement goals, the Governing Board established a system of achievement levels (*Basic, Proficient,* and *Advanced*) for all subject areas and grade levels included in main-NAEP assessments (Vinovskis, 1998).[17]

Subsequent legislation affecting NAEP and the Governing Board included P.L. 107-279, the Education Sciences Reform Act of 2002. Over time, the size of the Governing Board was increased and changes were made to the terms for board members and the process by which new members are chosen, as well as language defining the responsibilities of the Governing Board, NCES, and the Commissioner of Education Statistics. In particular, the LTT assessments were called out in the 2002 legislation, which states in section 302(e)(1)(F) that the Governing Board (referred to in the legislation as the Assessment Board) shall, "consistent with section 303, measure student academic achievement in grades 4, 8, and 12 in the authorized academic subjects." It goes on to specify in sections 303(a) and 303(b)(2)(F) that "The Commissioner for Education Statistics shall, with the advice of the Assessment Board established under section 302, … continue to conduct the trend assessment of academic achievement at ages 9, 13, and 17 for the purpose of maintaining data on long-term trends in reading and mathematics." Thus, although the Governing Board has the authority to determine the schedule for NAEP assessments, including the LTT, any Board recommendation that could affect that law would depend on the commissioner's concurrence, and the LTT could not be discontinued altogether unless the law itself were changed or superseded.

Consistent with its legislative mandate, beginning around 1990, the newly formed Governing Board introduced new frameworks for main-NAEP assessments, developed through a broadly consultative process. As a result, the mathematics assessments were dramatically revised in 1990 and then significantly expanded in 1992. The reading assessment was dramatically revised in 1992. These historic changes were summarized in the 1992 NAEP technical report as follows:

> **Reading**: For the national assessment, a newly developed reading assessment was administered at grades 4, 8, and 12. This assessment was designed around questions requiring in-depth analysis of authentic, naturally occurring reading materials. A mixture of multiple-choice, short constructed-response, and extended constructed-response questions made up the survey; in aggregate well over half of the student assessment time was spent answering constructed-response rather than multiple-choice questions. …
>
> **Mathematics**: For the nation, the assessment that had been developed in 1990 was nearly doubled in scope for 1992 and administered at grades 4, 8, and 12. Assessment tasks included the use of four-function calculators at grade 4, scientific calculators at grades 8 and 12, and open-ended problem-solving questions at all grades. Manipulatives, rulers, and protractors also were available for use with portions of the assessment. Extended constructed-response questions were used on a wide scale for the first time in a NAEP mathematics assessment. In addition, estimation was assessed using audiotapes that paced students through the questions,[18] and complex problem-solving skills were assessed for the nation in special study blocks. ... (Campbell, Lazer, and Mullis, 1994, pp. 33-34)

[17] NAEP achievement levels are not to be confused with the performance levels, discussed earlier, which are still used as an aid to interpretation of LTT assessment results.

[18] Use of audiotapes to pace students through questions calling for estimation is intended to encourage students to work quickly, discouraging them from taking time for exact calculations, which would defeat the purpose of the estimation exercise. This format had been used previously, and so, technically, was not a change in procedures.

These changes were so substantial that new IRT scales were developed and new trend lines started. Thus, since 1992, there have been separate score scales for main NAEP versus the LTT. Long-term trends in reading are reported on the same scale for 9-year-olds, 13-year-olds, and 17-year-olds. The scale has a nominal range from 0 to 500, but virtually all scores fall between 100 and 400. Long-term trends in mathematics are likewise reported on a common 0-500 scale for all three age levels. These scales have been in place since before 1990. Main-NAEP reading results are also reported on a 0-500 scale, and main-NAEP mathematics results at grades 4 and 8 are similarly reported. Since 2005, main-NAEP mathematics results at grade 12 have been reported on a separate, 0-300 scale. The details of scale construction are complex and beyond the scope of this paper, typically beginning with separate IRT calibrations for two or more subscales within a subject area and grade level, after which subscale scores are combined to create a composite scale. Scores on this composite scale are then re-expressed on the 0-500 or 0-300 reporting scales. Even though scores for different age or grade levels are finally reported on a common scale, it may not be meaningful to make direct comparisons between score distributions for different grades (for main NAEP) or for different ages (for the LTT).

From 1990 to 2000, there was little further investment in the LTT component of NAEP, which continued essentially unchanged through assessments in 1994, 1996, and 1999.[19] By 2004, when the next LTT assessment was to occur, it was clear that revisions were necessary. To begin with, by law, testing accommodations for students with disabilities and for English-language learners had to be provided. Main NAEP had begun offering such accommodations in 1996, which not only satisfied a legal requirement, but also enabled the inclusion of a higher proportion of students than before, bringing the main-NAEP assessments closer to the ideal of assessing the full populations of students at each grade level.[20] LTT exclusion rates had crept upward through the 1990s (Allen, McClellan, and Stoeckel, 2005, pp. 17-18), and so a higher participation rate for LTT assessments was also seen as a benefit of the revised accommodation policy. Also in 2004, the LTT in writing was terminated by NCES because design weaknesses made the results unstable; and the Governing Board chose to suspend the LTT in science, primarily because the science content of many LTT exercises was seriously out of date.[21] Other significant changes were made to the reading and mathematics LTT assessments, including updates to reading passages, exercise formats, and contextual (background) questions and needed revisions to assessment administration procedures, including updates to allowable testing accommodations. Removal of science exercises also enabled reconfiguration of LTT exercise booklets so that each student was assessed in only one content area. (Previously, LTT exercise blocks from different subject areas had sometimes appeared together.) In addition, "I don't know" was dropped as a distractor choice for LTT exercises (bringing LTT into conformity with main NAEP) and paced-tape administration was ended. NCES designed a bridge study to address these and other concerns. A special bridge study was conducted to evaluate the effects of these changes on LTT performance.[22] Elimination of paced-tape administration

[19] Note that "essentially unchanged" does not mean that there were no changes. In 1994, for example, three out of 195 LTT reading items were treated as "new items" and recalibrated because they appeared to be functioning differently in 1994 than they had previously (Chang, Donoghue, Worthington, Wang, andand Freund, 1996, p. 365).
[20] Private-school students are included in some but not all NAEP assessments. How private-school populations are framed and sampled, when they are included, and at what levels of aggregation their results are reported are all issues beyond the scope of this paper.
[21] The Board called for technical studies to investigate the feasibility of continuing the LTT science assessment at some point in the future (Governing Board, 2002; Stedman, 2009, p. 6).
[22] The 2004 LTT bridge study included assessment of some students following prior LTT assessment procedures as closely as possible. For this purpose, science exercise blocks were included in booklets along with LTT reading and

and reconfiguration of exercise booklets in the 2004 LTT assessments also made it possible to field test new LTT replacement items for the first time in two decades. Note that development of replacement items was guided by the NAEP mathematics objectives from 1981-82 and the NAEP reading objectives from 1979-80, as well as the items included in the LTT prior to 2004.

LTT data collections occurred again in 2008 and 2012 following the 2004 revised procedures, with no significant further modifications. These assessments used some new LTT exercise blocks field-tested and calibrated in 2004. This made it possible to release some blocks of LTT items, which are now publicly available via the NAEP Questions Tool at http://nces.ed.gov/NationsReportCard/nqt.

Main NAEP continued to evolve, with updated reading assessment frameworks in 2002 and 2009 and with updated mathematics assessment frameworks for 2005 at grades 4 and 8 and for 2009 at grade 12. For 2005, a new grade 12 mathematics framework was developed. There were minor revisions at other times to the reading and mathematics frameworks. Main-NAEP trend lines were maintained through these changes with the exception that the grade 12 mathematics trend line was ended and a new trend line was started in 2005.[23] These and other changes affecting trend lines are more fully described by Beaton and Chromy (2010, Ch. 3).

Various parts of NAEP's rich history are further documented elsewhere (e.g., Beaton and Chromy, 2010; Bourque and Byrd, 2000; Haertel and Mullis, 1996; Jones, 1996; Jones and Olkin, 2004; Mullis, 1992; Perie, Moran, and Lutkus, 2005; Stedman, 2009; Vinovskis, 1998; Zwick, 1992a, 1992b).[24]

A Note on Bridge Studies

When NAEP population definitions, frameworks, administration conditions, or in some cases, analysis procedures change, "bridge studies" are typically conducted to determine whether the change has a material effect on assessment results. The precise design of each bridge study depends on the particular change being investigated, but the idea is to conduct an assessment twice at the same time, following both the old and the new procedures. In that way, any differences observed can be attributed to the procedural change itself (after accounting for inevitable statistical variation). Typically, the assessment following the old procedures is conducted on a reduced scale (i.e., with smaller student samples).

Ideally, the bridge study will demonstrate that the effect of the procedural change is small enough to ignore. In that case, trend lines can be maintained without interruption. In the event that the bridge study

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mathematics items so as to avoid altering the context in which these reading and mathematics exercises were presented. The bridge study also examined the effects of new testing accommodations. Main-NAEP assessments in 1996 and 2000 had included subsamples assessed both with and without updated testing accommodations, and a similar, parallel data collection with and without updated accommodations was part of the 2004 LTT bridge study.

[23] As reported on the NCES website (https://nces.ed.gov/nationsreportcard/mathematics/frameworkcomparison.aspx), the 2009 revisions to the grade 12 mathematics framework "added objectives addressing mathematics content beyond what is usually taught in a standard 3-year mathematics course in high school … [so as to] help NAEP report how well prepared twelfth-grade students are for post-secondary education and training." A bridge study confirmed that, despite these framework revisions, grade 12 mathematics results from 2005 and 2009 were directly comparable, and so the new grade 12 mathematics trend line was continued from 2005 to 2009 without further interruption.

[24] Informative summaries also appear on the NCES website at http://nces.ed.gov/nationsreportcard/about/newnaephistory.aspx and http://nces.ed.gov/nationsreportcard/about/naephistory.aspx.

shows a material effect of some change, assessment results from old and new procedures can be compared to estimate the size of that effect. Again depending on the nature of the change, the interruption might or might not require defining a new set of NAEP reporting scales. Beaton explained bridge studies as follows, with reference to the original split in 1984 between main NAEP and the LTT:

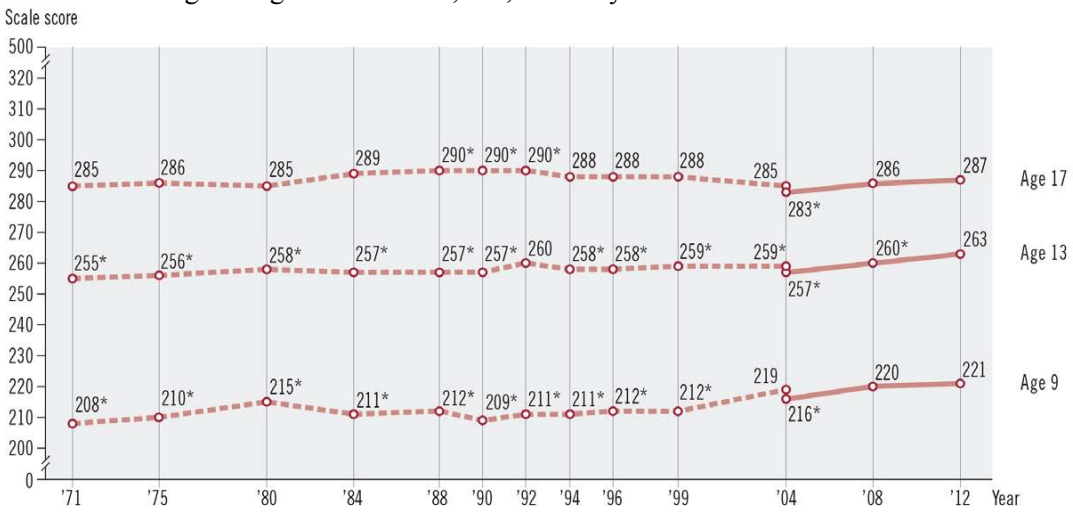
> It is useful at this point to consider the consequences of introducing a new design into an existing measurement system. There is a clear tension between the need to maintain constant measurement procedures in order to estimate changes in performance and the desire to continue to improve the assessment by using the most modern, best available technology. The new design introduced in 1984 responded to this tension by assessing student achievement in two ways: in one set of samples using the methods of past assessments and in another set using the best available methodology. The samples using the methods of the past were called "bridge" samples, since they provided bridges to the performance of students in past assessments. The result was parallel assessments, using different technologies, that could be compared and for some purposes, perhaps, equated. In this way, innovations could be introduced without losing comparability with the past. Although this flexibility to introduce innovations while maintaining trends has come at the cost of increased complexity, the flexibility does allow NAEP to be responsive to the information needs of policy makers while maintaining the scientific requirements of sophisticated survey research. (Beaton, 1990b, p. 5)

Even if some procedural innovation effects a material change, trend lines can often be maintained by simply incorporating the estimated effect of the innovation via some adjustment and continuing to report new observations on the old trend line. This has been the preferred approach. Whenever possible, such minor adjustments are simply absorbed into the scale transformations used to express IRT scale scores on NAEP reporting scales. A concern with this approach, however, is that the bridge study samples tested following old procedures are typically smaller, sometimes much smaller, than the samples for regular NAEP assessments. Consequently, bridge study estimates of the magnitudes of effects of procedural changes are somewhat imprecise, and so reliance on these estimates affects trend line accuracy.[25]

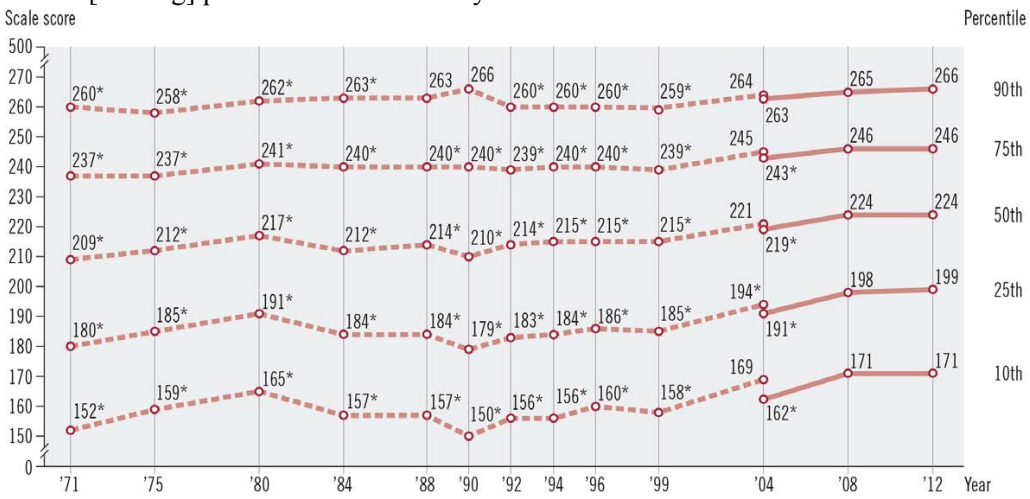
Unfortunately, the effects of changes in assessment frameworks, populations, or procedures cannot always be accounted for by scale adjustments. It may be difficult or impossible to maintain unbroken trend lines if the effects of a procedural change are markedly different for different parts of the tested population or if the definition of the assessed population itself is changed. This can be seen in the following two graphics taken from the 2012 NAEP LTT report (NCES, 2013, pp. 7-8):

[25] Comparisons of performance across greater spans of time will tend to be less accurate than those close in time, in part because random errors introduced by any intervening bridge study adjustments are cumulative, but also because there is some small, random error in linkages from one assessment to the next, even when procedures are unchanged. These year-to-year uncertainties will gradually accumulate over time.

Trend in NAEP reading average scores for 9-, 13-, and 17-year-old students



Trend in NAEP [reading] percentile scores for 9-year-old students



Note the breaks in trend lines shown at 2004. In the first of these graphics, it is seen that the average, overall effect for 9-year-olds of the various 2004 procedural changes to the LTT was to reduce the mean scale score in reading by 3 points, from 219 to 216. The asterisk indicates that this change was statistically significant. But the second, more detailed figure for only 9-year-old reading shows that the effect of the procedural changes was not a simple 3-point change everywhere in the distribution. At the 90th percentile, the effect was only 1 point (from 264 to 263), whereas at the 10th percentile, the effect was 7 points (from 169 to 162). The 2004 changes included new testing accommodations, so that under the new procedures, fewer students with disabilities were excluded. This subtly changed the definition of the tested population, in a way that affected primarily the lower part of the score distribution. As shown in the two graphics, when procedural effects prevent the direct comparison of old and new results, then trend lines must be restarted. In some such cases, new scales must be created. Both sets of bridge study results (i.e., old-procedure results and new-procedure results) are reported for the same year, each on its own trend line. Prior assessments can then be compared directly with bridge study results under old procedures, and future assessments can be compared directly with bridge study results under new procedures.

Future Plans for Main-NAEP Assessments in Reading and Mathematics

Preparations have been underway for some time for main NAEP to transition from paper-and-pencil to digitally based assessment. A new framework was adopted for writing, starting with the 2011 assessment at grades 8 and 12 and with the 2017 assessment at grade 4. This framework is computer-based, and so main-NAEP writing assessments at grades 8 and 12 have been computer-based since 2011. Current plans call for 2017 main-NAEP assessments in reading and mathematics, as well as writing at grades 4 and 8, to be conducted using tablets with keyboards.[26] A bridging study in 2017 will include smaller samples tested concurrently with paper-and-pencil test forms instead of tablets, so that administration mode effects can be monitored. The expectation is that mode effects will be accounted for in the scaling of digital exercises, and therefore, it will be possible to continue main-NAEP trend lines unbroken, pursuant to a Governing Board resolution adopted in May 2015.[27]

Summary

The Nation's Report Card offers two histories of achievement trends in reading and in mathematics, reported on separate, though similar, scales; for distinct, though similar, populations; covering different, though overlapping, time periods. LTT assessments from the early 1970s to 2012 are reported for schoolchildren at ages 9, 13, and 17 on LTT score scales; and main-NAEP assessments from the early 1990s to the present are reported for schoolchildren at grades 4, 8, and 12 on more recent score scales. There are also main-NAEP assessments from before 1990, reported for grade-based samples and sometimes for age-based samples on the earlier score scales still used for the LTTs.

Writing about the NAEP reading anomaly, Albert E. Beaton admonished, "*When measuring change, do not change the measure*" (Beaton, 1990a, p. 10, italics in original).[28] The narrative of the LTT has been that it has honored this admonition, serving as a stable anchor, measuring achievement in the same way, with the same frameworks, and mostly the same items since NAEP began. This account contrasts the LTT with main NAEP, which has been more adaptive in response to shifts over time in curriculum and instruction and to changing policy concerns, as well as new measurement innovations. The report on *NAEP 2004 Trends in Academic Progress* stated that "the long-term trend instruments do not evolve based on changes in curricula or in educational practices; in this way, the long-term trend assessments differ from the main national and state NAEP assessments" (Perie, Moran, and Lutkus, 2005, p. 91). In a paper commissioned for the 20th anniversary of the Governing Board, a former Governing Board member asserted in passing that "the LTT … consists of the same test questions in reading, mathematics, and science that were first offered in the 1970s" (Ravitch, 2009, p. 5). In another paper commissioned for that same anniversary event, Stedman further documented such assertions:

> The strongest argument for retaining the long-term trend assessment is that it has tested the same items for more than three decades and so has a unique ability to track changes. It is supposedly based on a single curricular framework and unchanging tests first administered in 1969 or the early 1970s. This is a widely held belief. Secretary Spellings described the assessment as “using

[26] The 2017 grade 12 writing assessment was cut from the schedule due to budget constraints. Digitally based writing assessments at all three grade levels are scheduled for 2021.

[27] See https://www.nagb.org/content/nagb/assets/documents/policies/resolution-on-trend-and-dba.pdf.

[28] As noted in an earlier footnote, it is not quite accurate to refer to the comparison described as a measure of "change," because two distinct samples, representing two distinct populations, are being compared. Nonetheless, the shorthand reference to "change" should cause little difficulty so long as the actual nature of the comparison is not forgotten.

> the same exact test in reading and mathematics for over 30 years" (U.S. Department of Education, 2005). NCTM (2004) noted, "The same test items have been used for mathematics since 1973." Even NCES … perpetuates this view, stating that content "has remained essentially unchanged since first administration (1971 for reading, 1973 for mathematics), although some changes were initiated in 2004."[29] (Stedman, 2009, p. 28)

As this brief review has shown, however, the reality is that both main NAEP and the LTT have changed over time. In the sentence following his admonition to "… *not change the measure*," Beaton (1990a, p. 10) continued, "Precise implementation of this dictum is, of course, impossible in actual practice. In fact, NAEP has modified its measurement instruments by rearranging and reformatting assessment exercises since it began measuring trends." Zwick (1992b, p. 206) likewise acknowledged that, "Like any long-term study of trends in educational achievement, NAEP is subject to competing pressures … On one hand, the measurement of changes in performance is facilitated by the retention of existing assessment instruments, administration procedures, and analysis techniques. On the other hand, requiring the assessment to remain identical over time would prevent the introduction of new curriculum concepts and measurement technology."

Stedman (2009) recounted some of the same history as set forth in this paper, amply attesting to significant changes in LTT content and administration procedures prior to 1990. In an appendix, by way of illustration, he provided the numbers of linking items (exercises) used at various times to maintain trend lines for 17-year-olds. For reading, these links were based on 71 items in 1980, 53 items in 1984, and 87 items in 1988. For mathematics, among other details, Stedman reported that just 61 items were used to link the 1978 and 1982 assessments for 17-year-olds. Total numbers of items (i.e., linking items plus additional items administered and calibrated along with linking items) also varied widely across LTT assessments, both in reading and in mathematics.

Throughout the 1990s, the LTT was in fact continued virtually unchanged, but this effort to follow Beaton's dictum not to change the measure, using the same test forms for years, resulted in cumulative obsolescence, which ironically may have impaired NAEP's ability to measure change. The meanings of fixed items can and do change over time. This is abundantly clear in science, but it is seen to a greater or lesser extent in all subject areas. Today, all NAEP assessments, including the LTT since 2004, are designed in a way that permits retiring old, obsolete items and replacing them with fresh items that measure the intended framework or objectives.

All this is not to deny that the LTT has measured the same content for decades. Since the mid-1980s, the LTT has continued to represent content defined by the NAEP mathematics objectives from 1981-82 and the NAEP reading objectives from 1979-80, subject to some curtailment because not all early items could be scaled. Even when the LTT was updated in 2004, an effort was made to "reverse-engineer" the objectives underlying the existing LTT item pools so that new LTT items could be added without

[29] The quotation Stedman provides from the NCES website, at http://nces.ed.gov/nationsreportcard/about/ltt_main_diff.aspx, has since been updated, and now correctly explains that content "has remained relatively unchanged since 1990. In the 1970s and '80s, the assessments changed to reflect changes in curriculum in the nation's schools. Continuity of assessment content was sufficient not to require a break in trends." Likewise, as compared with the *NAEP 2004 Trends* report, the language in the report on *NAEP 2012 Trends in Academic Progress* (NCES, 2013) is more cautious, and more accurate, in describing the continuity of the LTT prior to 1990.

changing the constructs assessed.[30] And, although reading and mathematics objectives evolved during the 1970s, the LTT does provide some linkage all the way back to the very first NAEP reading and mathematics assessments in the early 1970s. It does not, however, continue to reflect the curriculum content or the educational priorities of NAEP's very beginning.

Further significant changes loom as main NAEP continues the transition to a digital platform in 2017. These changes might be taken to imply that the LTT is increasingly irrelevant, or that the LTT is more important than ever. Regardless, the LTT assessment for 2016 has been twice postponed, first to 2020 and then to 2024. The LTT stands at a critical juncture. Its future is unclear.

What Do the LTT Assessments Measure?

Before turning to options for the LTT's future, it may be helpful to review publicly available information as to just what it is that the LTT assessments in reading and mathematics actually assess. This question turns out to be surprisingly difficult to answer. Recall that there are no fully developed content frameworks for the LTTs. Rather, the LTTs began as collections of exercises, operationalizing lists of objectives that changed over time. Some fraction of those exercises survived being released (i.e., were kept secure for reuse) and also survived screening on technical criteria, screening for bias, screening for outdated or obsolete content, or elimination on any other grounds. These surviving exercises, sometimes revised, augmented with some additional exercises intended to measure the same content, became the LTT exercise pools.

The NCES website (https://nces.ed.gov/nationsreportcard/ltt/moreabout.aspx) offers the following description of what is measured by the LTTs in mathematics and reading, and much the same language appears in recent NAEP trend reports:[31]

> **Mathematics:** The long-term trend mathematics assessment required students to respond to a variety of age-appropriate questions. The assessment was designed to measure students'
>
> - knowledge of mathematical facts,
> - ability to carry out computations using paper and pencil,
> - knowledge of basic formulas such as those applied in geometric settings, and
> - ability to apply mathematics to daily-living skills such as those involving time and money.
>
> …
>
> **Reading:** The NAEP long-term trend reading assessment measures students' reading comprehension skills using an array of passages that vary by text types and length. The assessment was designed to measure students' ability to
>
> - locate specific information in the text provided,
> - make inferences across a passage to provide an explanation, and

[30] This "reverse-engineering" may be described in internal contractor documents, but there are no LTT frameworks comparable in scope and organization to NAGB-developed frameworks for main NAEP. Formally developed and adopted frameworks and specifications for the LTT would be enormously helpful in systematizing the ongoing creation of replacement items, especially if the LTT transitions to a digital platform.

[31] Stedman (2009, pp. 29-30) also summarizes several brief descriptions of LTT content from earlier NCES reports, some of which appear inconsistent with one another.

- identify the main idea in the text.

Some released LTT exercises are available on the NCES website, formatted as a "Sample Questions Booklet."[32] These include both multiple-choice and constructed-response exercises for both reading and mathematics. The 2011-12 "Sample Questions Booklet" also includes more detailed descriptions of LTT content for the 2011-12 assessments in both mathematics and reading at all three age levels assessed (included as Appendix A to this paper). The descriptions of the five content topics in mathematics paraphrase parts of the "content outline" included as Appendix C in the *1981-82 NAEP Mathematics Objectives* (NAEP, 1981a, pp. 33-35), although language is updated, some subtopics have been removed and a few added, and a sixth category from the *1981-82 Mathematics Objectives* ("technology") has been omitted. Likewise, the descriptions of four mathematics "process domains" largely quote or paraphrase the first four of the five "process" categories from the 1981-82 objectives (NAEP, 1981a, pp. 14-16), with the fifth category ("attitudes toward mathematics") being omitted. The "target percentages" by content topic for each age level differ from those presented in the 1981 document.

The description of the LTT in reading in the 2011-12 "Sample Questions Booklet" may be based in part on the *Reading Report Card* reporting trends in reading from 1971-84 (NAEP, 1985), although it includes considerable detail not found in that trends report. As with mathematics, the reading description appears to have been updated slightly from similar descriptions published in sample questions booklets from the 2003-04 and from 2007-08 LTT assessments. The classification of exercises into categories of "expository, ""narrative," and "document and other" was not located in any previous NAEP reading objectives documents, and no percentages of items by text type appear in the sample questions booklets from earlier assessments.

LTT content was examined in a recent study by Dickinson, Taylor, Koger, Moody, Deatz, and Koger (2006). These researchers documented the alignment between (1) the 2004 LTT exercises in reading and mathematics at ages 9 and 13 and (2) the 2003 main-NAEP assessment frameworks[33] and exercises in reading and mathematics at grades 4 and 8. Dickinson and her colleagues lamented the absence of any LTT content frameworks that they would otherwise have compared with main-NAEP frameworks, but they were able to report that, overall, they rated both main NAEP and LTT items as being of high quality. Referring to Webb's (1997, 1999) system for coding "depth of knowledge," they also reported that "it is clear that Main NAEP items tend to assess higher depth of knowledge levels than LTT items. In other words, students must use complex processing more often to answer items for Main NAEP than for LTT items" (Dickinson, et al., 2006, p. 21). In the end, these authors concluded that "the LTT and Main NAEP assessments measure specific content objectives that are different, and therefore the two assessments cannot be considered interchangeable. … Main NAEP targets content that is not being measured by LTT test items. [Conversely], though LTT items can be linked to general-level content strands within the Main NAEP frameworks, … if a subset of Main NAEP items were selected in an attempt to replace the LTT item pool, matching the content intentions of the LTT assessment would be difficult if not impossible given the lack of LTT content frameworks" (Dickinson, et al., 2006, p. 24).

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[32] See http://nces.ed.gov/nationsreportcard/subject/_commonobjects/pdf/demo_booklet/2011_12_sqb_ltt.pdf. Individual released exercises from 2004 and 2008 may also be viewed using the NAEP Questions Tool. To view these exercises, beginning at http://nces.ed.gov/NationsReportCard/nqt, choose "Search Questions," then select either "LTT Mathematics" or "LTT Reading" in the "Select Subject" pull-down menu and proceed accordingly.

[33] Note that these main-NAEP frameworks have since been revised.

So, accepting the summary descriptions on the NCES website and in NAEP reports, as well as the summaries and the released exercises themselves from the sample exercise booklet accessible online, we may conclude that the content and processes assessed by LTT exercises fall within the range of typical curricular expectations for grades 4, 8, and 12, but that more advanced topics and more complex processes at these grade levels are largely omitted. It is likely that many LTT exercises at ages 9, 13, and 17 are better aligned with contemporary curriculum and instruction at grades 3, 7, and 11, respectively, than grades 4, 8, and 12. Based on inspection of the released exercises in the "Sample Questions Booklet," none of the released exercises available appears to be out of date, nor are there any that appear likely to be judged by thoughtful and knowledgeable reviewers as inappropriate or as addressing content that should not be taught. There would probably be consensus that the LTT omits many important topics, although it might be difficult to reach agreement as to exactly what those important omitted topics were. Obviously, these matters could best be informed by systematic studies of the entire LTT exercise pool.

Arguments For and Against Preserving the LTT in Its Current Form Versus Dropping It Altogether

As already described, Title III of P.L. 107-279 (titled the "National Assessment of Educational Progress Authorization Act") requires that the Commissioner for Education Statistics "continue to conduct the trend assessment of academic achievement at ages 9, 13, and 17 for the purpose of maintaining data on long-term trends in reading and mathematics." In addition to this statutory requirement, most arguments for maintaining separate LTT assessments are premised on one or both of the following propositions:

- LTT assessments are unique in tracking achievement over a very long time span.
- LTT assessments measure knowledge and skills that are both important and distinct from what is measured by main-NAEP assessments.

With some qualifications, the historical review and content summary in this paper support both of these contentions. The LTT assessments might best be regarded as an anchor, assessing a fairly low-level, traditional subset of contemporary curricular objectives. For mathematics, comparison of the LTT content area distributions in Appendix A with the percentage distributions by grade and content area in the *2013 Main-NAEP Mathematics Framework* (Governing Board, 2012) confirms that the LTT places much greater weight on numbers and numeration, especially at ages 13 and 17, than the main-NAEP framework places on "number properties and operations," especially at grades 8 and 12. For reading, comparison of the LTT descriptions in Appendix A with the *2015 Main-NAEP Reading Framework* (Governing Board, 2015) confirms that the LTT places more weight on expository texts at age 9 than does main-NAEP reading at grade 4. Also, at all three grade levels, the LTT relies on shorter reading passages than main NAEP (up to 250, 500, and 800 words for ages 9, 13, and 17 on the LTT versus up to 800, 1,000, and 1,500 words for grades 4, 8, and 12 for main NAEP, respectively). Although information is less readily available concerning differences in the skills and thinking processes elicited by main NAEP versus the LTT, comparison of the brief descriptions of LTT target skills on the NCES website versus current main-NAEP frameworks in reading and mathematics, as well as the depth-of-knowledge comparisons presented by Dickinson and colleagues (2006), suggests that main-NAEP exercises by and large call for more complex reasoning as well. For both content areas, then, the LTT appears to assess a subset of main-NAEP content and skills, although as noted by Dickinson and colleagues (2006), it might be difficult to delineate subsets of main-NAEP exercises that mirrored the LTT exercise pools.

A more specific argument in favor of continuing the LTT in its current form is the risk of jeopardizing long-term trends if the LTT were modified. This argument might carry more weight in light of impending

major changes, as main NAEP continues its transition to a digital platform. Keeping the LTT component unchanged might be viewed as an "insurance policy" in the event of unforeseen problems akin to the 1986 reading anomaly, although a counterargument would be that, with the next LTT now scheduled for 2024, the LTT would be of little help in any case if main-NAEP trends were compromised in 2017.

It can also be argued that, in addition to being required by law, the LTT's age-based achievement trends offer a valuable counterpoint to the grade-based trends from main NAEP. Contrasts between age-based and grade-based gaps and trends might inform contemporary policy questions arising from the societal trend toward children starting formal schooling at a later chronological age (Deming and Dynarski, 2008) as well as differential rates of grade retention for different racial/ethnic groups (Nagaoka and Roderick, 2004). Performance trends over time for 13-year-olds (rather than eighth graders) might also serve as a better basis for comparison with performance trends on international assessments that also rely on age-based samples. Even apart from such specific policy questions, the fact that fourth graders today are, on average, older than fourth graders 10 or 20 years ago confounds the interpretation of trend lines for successive fourth-grade cohorts, and similarly for 8th and 12th graders. Age-based trend lines therefore offer important context for interpretations of grade-based trend lines.

Finally, as main NAEP evolves in response to changing curricular priorities and expectations for schooling outcomes, both proponents and critics of reforms such as the Common Core State Standards may wish to document achievement trends brought forward from an earlier, perhaps simpler, time, to see whether more "basic skills" are compromised by increasing emphasis on more complex learning objectives. One of the original architects of NAEP, Lee J. Cronbach (1963), argued for the importance of testing potentially valued instructional objectives *not* emphasized in a given curriculum. The same argument can be elevated from the level of course evaluation to the level of achievement profiles for the nation's youth:

> An ideal evaluation would include measures of all the types of proficiency that might reasonably be desired in the area in question, not just the selected outcomes to which this curriculum directs substantial attention. If you wish only to know how well a curriculum is achieving its objectives, you fit the test to the curriculum; but if you wish to know how well the curriculum is serving the national interest, you measure all outcomes that might be worth striving for. One of the new mathematics courses may disavow any attempt to teach numerical trigonometry, and indeed, might discard nearly all computational work. It is still perfectly reasonable to ask how well graduates of the course can compute and can solve right triangles. Even if the course developers went so far as to contend that computational skill is no proper objective of secondary instruction, they will encounter educators and laymen who do not share their view. If it can be shown that students who come through the new course are fairly proficient in computation despite the lack of direct teaching, the doubters will be reassured. If not, the evidence makes clear how much is being sacrificed. (Cronbach, 1963, p. 680)

The principal arguments against maintaining the LTT in its current form are that it is expensive, that maintaining two trends is confusing, that performance on outdated content is no longer of interest to policymakers or other stakeholders, and that a range of changes in schooling, in assessment technology, and in society at large are rendering it irrelevant and possibly invalid.

Cost concerns seem always to have weighed heavily on discussions of NAEP assessment schedules, including the decisions to postpone the next LTT data collection first to 2019-20 and then to 2023-24.

Resources are limited, and trade-offs among competing priorities are inevitable. It is difficult to pursue this argument any further here, because that would require delving into the specifics of costs for the LTT and for competing NAEP priorities and then weighing these against perceived benefits, all within the constraints of historical commitments and statutory requirements.

The argument that the LTT should be discontinued because having two trends is confusing seems weak. This argument was advanced in the National Research Council report, *Grading the Nation's Report Card* (Pellegrino, Jones, and Mitchell, 1999, p. 73), but as argued by Stedman (2009), disparate findings from LTT versus main-NAEP trends might equally well be cited as support for *maintaining* both assessment components, so as to better understand sources of differences. Beaton and Chromy (2010) found that for time periods where main-NAEP and LTT trend lines overlap, they do not entirely agree. After documenting procedural differences that complicated direct comparison of main-NAEP versus LTT findings, these authors explained their procedure for transforming reported results for the two assessment components into a common form. They then compared annual changes expressed as scale points per year for reading and for mathematics, comparing 9-year-olds assessed on the LTT with 4th graders assessed in main-NAEP and similarly for 13-year-olds and 8th graders and for 17-year-olds and 12th graders. They discussed whether annualized changes from main NAEP and from the LTT were statistically different from zero and also whether these changes for the two assessments were statistically different from one another. Although some differences between the two assessments appeared substantively meaningful, virtually none were statistically significant. This was unsurprising given the low power to detect differences (between assessments) in differences (over years, as captured by regression coefficients representing fitted trend lines).

A related argument holds that LTT trend lines are becoming redundant now that main-NAEP trend lines reach back more than 25 years. This argument also seems weak for three reasons. First, as shown in Figure 1, the LTT trend lines still cover a long and significant historical period not covered by main-NAEP trend lines. Although the historical LTT trend line would still be available if the LTT were discontinued, information about contemporary performance on LTT content would be lost, and direct comparisons with that historical period would no longer be possible. Second, LTT trend lines in mathematics have been interrupted, and when the reading framework was revised in 2009, it was an open question whether trend lines could be maintained. Future interruptions of main-NAEP trend lines are likely. Finally, main NAEP and the LTT assess distinct mixes of academic content and skills, reflecting distinct curricular priorities. The more stable, more conservative LTT trend lines provide a valuable counterpoint to the more adaptive main NAEP trend lines, which reflect more contemporary conceptions of valued schooling outcomes.

As to the idea that having two trend lines per se is simply confusing, a measurement specialist might counter that much mischief has arisen from the naive notion that "a test measures what it says at the top of the page" (Braun and Mislevy, 2005, p. 492). No one is well served by hiding evidence that not all reading tests, nor all mathematics tests, measure the same thing.

The argument that performance on outdated content is no longer of interest to policymakers or other stakeholders has already been addressed. Long-term trends will certainly not be of interest to everyone,

but as noted, both advocates and skeptics of recent curriculum reforms may wish to continue tracking achievement trends that reach back to a time before those reforms were initiated.[34]

Arguments that changes in schooling, technology, and society at large are rendering the LTT obsolete require more careful consideration. As the day-to-day activities of schooling evolve over the years, test tasks that once seemed familiar may come to seem foreign. Specific kinds of math problems that were once practiced by eighth graders but are now taught at earlier grade levels may have become more challenging when appearing on eighth-grade examinations. As children come to spend proportionately more time working in groups or applying mathematics and reading skills in the context of more complex, project-based instructional activities, or as assessment is better integrated into instructional activities and separate, stand-alone tests are used less often, the routines and expectations of the testing situation may become less familiar, and students' test performance may be affected. Indeed, "as a result … labels such as reading and writing do not necessarily retain the same meaning over time … and may not mean the same thing for bridge and main assessments that occur within a single year" (Zwick 1992b, p. 207).

Approaches to Integrating (or Blending) LTT and Main-NAEP Assessments

It would seem ideal, perhaps, to find some middle way between continuing the LTT unchanged and discontinuing it altogether. The goal would be to realize the benefits of maintaining the LTT while minimizing the costs. To summarize, in addition to the requirement in law that the LTT be continued, the principal benefits include maintaining long-term trends reaching back to the 1970s; reporting separately on still-relevant achievement outcomes dating from the days before the Common Core State Standards; and maintaining trends on achievement for populations defined by age, to complement main-NAEP assessments of populations defined by grade level. The costs include dollar costs; increased complexity of data collection, analysis, and reporting; and the testing burden.

Compromise positions that reject both continuing the LTT unchanged and dropping it altogether have been advanced repeatedly. In a unanimously adopted policy statement, the Governing Board called for a transition toward making main NAEP the primary source of information for trend reporting, while continuing LTT assessments on a less frequent basis (Governing Board, 1996, pp. 9-10). Since then, the NAEP program has in fact shifted in that direction. As shown in Figure 1, LTT assessments have become less frequent and main-NAEP trend lines have grown to cover longer and longer periods of time. The 1996 Governing Board statement also called for periodic updates to the LTT, with bridging studies to maintain trends, and an update of the sort envisioned was enacted a few years later, via the 2004 LTT bridge study.

A similar proposal was advanced in an NRC evaluation of NAEP, *Grading the Nation's Report Card*. That report called for "[reducing] the number of independent large-scale data collections [referred to in the report, using terminology current at the time, as national NAEP, state NAEP, and trend NAEP] while maintaining trend lines, periodically updating frameworks, and providing accurate national and state-level estimates of academic achievement" (Pellegrino, Jones, and Mitchell, 1999, p. 56).

[34] A reviewer raised the possibility of tracking performance on earlier content by analyzing a subset of main-NAEP items. As noted by Dickinson, et al. (2006), it is not clear how, or even if, a subset of main-NAEP items aligned with the objectives assessed by the LTT could be identified.

The technical challenges in fully merging main-NAEP and LTT assessments are daunting, however, perhaps even insurmountable. In addition to distinct exercise pools and the absence of well-defined frameworks for LTT assessment content and target skills, differences between LTT and main-NAEP assessments include sampling from populations defined according to age versus grade level; different testing windows (i.e., testing at different times during the school year); and incompatible exercise booklet formats (with three 15-minute versus two 25-minute blocks of cognitive exercises). Past experience, including the 1986 reading anomaly, has shown that even small changes in procedures can disrupt trend lines. Thus, simply merging LTT exercises into main-NAEP booklets would carry the risk of seriously disrupting both LTT and main-NAEP trend lines.

A general caution concerning changes to NAEP procedures appeared in a 2012 white paper on possible directions for a NAEP redesign. As part of its initiative on the future of NAEP, NCES convened a diverse group of technical experts for a summit meeting in August 2011 and a group of state and local stakeholders for a second summit meeting in January 2012. A panel of experts was then assembled to synthesize the presentations and discussions from these two meetings. That panel prepared a white paper in which they cautioned that even "seemingly innocuous changes in the underlying survey and psychometric models can take years to understand and validate, and more years before they become part of NAEP operations." Nearly all of that Expert Panel's recommendations were to initiate investigations of promising potential improvements to NAEP infrastructure and operations; few were for immediate changes (Expert Panel on the Future of NAEP, 2012, p. 9).[35]

In a background paper commissioned to inform work of the NRC committee that authored the 1999 report on *Grading the Nation's Report Card*, Kolen (2000) offered a thoughtful analysis of options concerning the LTT. These included continuing the LTT under explicit guidelines permitting small, periodic updates; eliminating the LTT (following linking studies to connect main-NAEP and LTT trend lines as best possible); and modifying main NAEP so that main-NAEP results could be reported on both LTT and main-NAEP scales. These were Designs 2, 3, and 4 in Kolen's paper. His Design 1 was the continuation of the separate LTT, unchanged. He concluded that the most conservative choice, maintaining a separate LTT unchanged, was safest in the sense of providing the greatest assurance that long-term trends could be continued, and also (probably) providing the best insurance against distortions to trend lines in the event that main NAEP began to drift toward high-stakes uses (a threat salient at the time of his writing, in the light of discussions around a possible "voluntary national test").[36] Many of the changes Kolen recommended in connection with his Design 2 (a separate LTT with periodic modest updates) were in fact carried out some years later in the 2004 LTT bridge study. Concerning his two remaining possibilities (either linking or integrating the two NAEP components), Kolen cautioned that:

> Both designs require conducting complex linking studies, making strong statistical assumptions, and being supported by an extensive research program for developing linking procedures that work in the NAEP context. The outcome of this research program is difficult to predict. Possibly, procedures could be developed that allow for linking assessments as different as long-term trend NAEP and main NAEP or as different as new and old main NAEP. However, it is also possible

[35] The author of this paper, Edward Haertel, also chaired the Expert Panel on the Future of NAEP.

[36] Note that, then as now, NAEP law prohibited any reporting of individual student or school results. Very briefly, the concern at the time was that if a "voluntary national test" were created, aligned with NAEP frameworks, and if individual scores from such a test were reported in metrics resembling NAEP scales, then the motivational context for future NAEP assessments might be altered.

> that the results of the research will indicate that changes in main NAEP assessments need to be much more tightly constrained than is presently the case. (Kolen, 2000, p. 148)

Kolen's analysis provides helpful background, but his paper did not address the fact that LTT versus main-NAEP data collections occur at different times in the school year. Because this appears to be a major challenge in combining the two assessments, and because both the LTT and main NAEP have changed significantly since Kolen was writing almost 20 years ago, the specific details of his proposals are not considered further in this paper.

The plan discussed below differs substantially from any of Kolen's (2000) options. It would preserve separate reporting of LTT and main-NAEP trend lines following a partial integration of main NAEP and the LTT. It would be expected to result in significant cost savings and to increase the long-term viability of the LTT. This plan would require bridging LTT trend lines (as happened in 2004) but would not be expected to have any material effect on main-NAEP procedures or trend lines. Note that in the following discussion, it is convenient to stay with the terminology of "booklets," even though, with the move to a digital platform, paper-and-pencil booklets may no longer be used. It is convenient to assume here that the main-NAEP BIB-spiral design will be maintained, with two exercise blocks (plus contextual questions, etc.) in the booklet administered to each examinee, and that the main-NAEP sampling design will be largely unchanged, although the options proposed here do not depend critically on either of these assumptions.

Testing Window and Assessment Platform

The 2004 LTT bridge study brought the LTT into closer correspondence with main NAEP, but substantial differences remain. LTT data collections still occur in the fall for 13-year-olds, in the winter for 9-year-olds, and in the spring for 17-year-olds, in contrast to the January-March main-NAEP data collection window at all three grade levels. The LTT still samples student populations defined by age, not grade. Most important, of course, the content assessed by the LTT differs from that assessed by main NAEP. In addition, contextual questions, used as conditioning variables in the complex NAEP scoring process, are different for main NAEP versus the LTT, although as noted by a reviewer, changes to conditioning variables need not disrupt trends, provided the specific variables used to define reporting subgroups remain unchanged. Another major divergence between main NAEP and the LTT looms, with the impending transition of main NAEP reading and mathematics assessments to a digital platform. Finally, as already noted in passing, NAEP achievement levels (*Basic, Proficient,* and *Advanced*) are defined only for main-NAEP reporting, whereas LTT results are still reported in terms of performance levels defined by the earlier scale anchoring procedure.

Content differences between main NAEP and the LTT stand as one of the main rationales for maintaining the LTT, and arguments have been presented for maintaining age-based sampling for the LTT as well. The case for maintaining data collections at different times of the year, however, appears much weaker. Regarding the main-NAEP digital platform transition, a strong argument can be made for also shifting the LTT to a digital platform as soon as possible.

Changing the LTT testing windows to bring them into alignment with the main-NAEP testing window would bring several advantages. First, the sampling designs for main NAEP and the LTT could then be integrated, resulting in significant cost savings. Second, these savings might make it possible at the same time to expand LTT samples somewhat to include oversampling of minority groups, thereby improving LTT estimates of achievement gaps and subgroup trends, as recommended by Barron and Koretz (1996).

Third, for technical reasons, integrating the two samples would increase the precision of contrasts between main-NAEP versus LTT gaps and trends.[37] This change might also reduce costs by enabling better synchronization of schedules for main-NAEP versus LTT data analysis and reporting.

Facility with the format and conventions of paper-and-pencil testing per se seems peripheral to the kinds of inferences that educators, policymakers, and the public at large are most likely to wish to draw from LTT performance and performance trends. Indeed, paper-and-pencil testing might become a liability. As children become increasingly accustomed to digital devices, their performance on paper-and-pencil assessments might decline for reasons unrelated to their proficiency with the content and skills assessed, including diminished motivation to write out responses long-hand and declining familiarity with hard-copy answer booklets. The future is difficult to predict, but given that the next scheduled LTT assessment is not until 2024, continued reliance on already outmoded assessment technology is a serious concern. Another argument against continued paper-and-pencil testing is the greater cost of producing, shipping, collecting, scanning, and scoring hard-copy testing materials. In this regard, NCES provided the following statement in the course of its review of this white paper:

> **Feasibility of maintaining LTT NAEP as a paper-based assessment**
>
> By the next LTT assessment administration in 2024, Main NAEP will have transitioned completely to a digitally based assessment (DBA). LTT, however, continues to be a paper based assessment (PBA). Delivering assessments via both formats would require supporting two test delivery systems with different administrative procedures. Specifically, under that scenario, various processes and procedures would need to be reinstituted solely for LTT, including booklet printing, booklet shipping, booklet processing, data transfer, and constructed-response scoring. Maintaining paper for the LTT would therefore, require an additional parallel set of resources to accomplish this work and would be cost prohibitive. Moreover, administration procedures appropriate for the separate PBA would need to be reinstituted. For example, while separate trainings would be required for Main NAEP and LTT regardless of the format of LTT, maintaining LTT as a paper-based assessment would now require two different sets of procedures for field staff training, for which separate quality control procedures would have to be developed and implemented. Given these challenges, NCES posits that maintaining a paper-based LTT in the context of a fully digital Main NAEP is largely infeasible.

These considerations give rise to recommendations for two major updates to the LTT design. One substantial, but manageable, design change would be to shift the LTT testing windows so that all LTT and main-NAEP testing occurred at the same time. A second substantial, but manageable, design change would move LTT assessments from paper-and-pencil booklets to digital assessments. These two updates might be considered independently, but in the interest of minimizing the number of bridge studies and trend line interruptions required, it seems most sensible to investigate both at the same time.

Testing windows. Under this LTT redesign proposal, sampling frames for main NAEP and the LTT would be integrated. When main-NAEP student samples were drawn, LTT student samples would also be

[37] Positive sampling error covariances between the main-NAEP and LTT components of the NAEP assessment program, arising from use of the same primary sampling units (PSUs), would increase the precision of contrasts between main-NAEP and LTT estimates.

drawn, in a subset of the same schools.[38] Slightly larger numbers of 9-year-old 4th graders, 13-year-old 8th graders, and 17-year-old 12th graders would be tested, together with supplemental samples of 9-, 13-, and 17-year-olds not at these modal grade levels. Thus, a single sampling plan would include both grade-based main-NAEP samples and age-based LTT samples. Sample integration might also enable better alignment between main-NAEP and LTT contextual variables used for conditioning estimates in the MML/multiple imputation analysis plan. As noted, particular care would be required in updating any contextual variables used in defining separately reported subgroups.

Changing the LTT testing windows would also require redefining the ranges of birthdates framing each age cohort. (For example 13-year-olds in the fall are not the same group as 13-year-olds in January through March.) Definitions of LTT age cohorts have shifted from time to time, with current definitions from January 1 to December 31 for 9-year-olds and 13-year-olds, and October 1 through September 30 for 17-year-olds. Because the current LTT testing window for 9-year-olds (January through March) matches the main-NAEP testing window, presumably, the age cohort definition for 9-year-olds would remain unchanged. Cohort definition for 13-year-olds might also remain unchanged, but the October 1 through September 30 cohort definition for 17-year-olds would require attention.[39] The way the 17-year-old age cohort is currently defined, this group's modal grade is 11, not 12. For the 2012 LTT, for example, age 9 students were defined as those born during 2002 (and were therefore 9 years old as of January 1, 2012). Age 13 students were those born during 1998. However, age 17 students were those born between October 1, 1994, and September 30, 1995, a shift of nine months relative to the calendar-year definition that would correspond most closely to the definitions used for ages 9 and 13. Given that LTT assessments occur in the fall for 13-year-olds and the following spring for 17-year-olds, there is a justification for this disparity. However, with the shift to a common testing window, these discrepant age cohort definitions might be changed.

Transition to digital platform. Under this LTT redesign proposal, LTT exercises would be migrated to a digital platform. This change would be planned so as to minimize changes to exercises. For most modern assessments, digital testing may be viewed as an affordance for greater flexibility in assessing a broader range of cognitive skills using new, often interactive, item formats (Bennett, 2015; Drasgow, Luecht, and Bennett, 2006; Expert Panel on the Future of NAEP, 2012). For the LTT, however, the digital platform would in effect be little more than an "electronic page-turner," that is, a device for presenting stimuli and recording responses using items originally designed for paper-and-pencil tests. In addition to new item formats, digital platforms also support significant improvements to testing accommodations for students with disabilities and possibly for English-language learners, better approaching the ideal of "universal design" (Way, Davis, Keng, and Strain-Seymour, 2016). Even at the risk of diminished comparability with past assessment results, making such improvements to available accommodations as part of a digitally based LTT would seem to be a sound investment in more accessible and thereby more valid measurement for the broadest possible range of students, as well as enhanced comparability with main-NAEP assessment results. Issues to consider in the transition of the LTT to a digital platform would

[38] LTT samples need only be large enough to estimate achievement distributions for populations and subgroups at the national level, whereas main-NAEP, at least at grades 4 and 8, also provides estimates at the state level. It is possible that LTT sampling might require some slight augmentation of the pool of main-NAEP schools to include students within LTT age definitions but outside modal grade levels. Because state-level reporting for grades 4 and 8 already requires larger NAEP samples, such augmentation to the pool of main-NAEP schools is most likely to be required for 17-year-olds.

[39] Explicit LTT age cohort definitions may be found at https://nces.ed.gov/nationsreportcard/ltt/sampledesign.aspx.

include typing (versus writing) extended responses, especially for 9-year-olds, and mathematical computations possibly using scratch paper.

A bridge study would be required, involving the testing of at least two groups of 9-year-olds, at least two groups of 13-year-olds, and at least two groups of 17-year-olds. At ages 13 and 17, some students would be tested during the current LTT testing window and the remainder during the January-March main-NAEP testing window. For LTT 9-year-olds and main-NAEP fourth graders, the testing windows already coincide, and so the two LTT bridge study 9-year-old samples would be randomly equivalent. At age 13, the samples would be drawn using identical (calendar-year) age cohort definitions, but might differ subtly due to patterns of student mobility over the course of the school year. Note that mobility almost certainly affects demographic subgroups differentially. Mobility effects, as well as the effects of maturation and schooling between the fall LTT testing window and the January-March main-NAEP testing window, would be absorbed into the mix of effects accounted for by the bridge study. At age 17, there would be a nine-month offset in the range of birthdates included in the respective sampling frames. This effect, along with effects of mobility and high school dropout, as well as procedural changes, would all be confounded in the effects estimated by the bridge study. Acknowledging the impact on LTT trend lines, the bridge study would support a transition to efficient, workable LTT sampling frames for 13- and 17-year-olds, as well as 9-year-olds, all tested during the main-NAEP testing window.

In addition, the bridge study would test some students at each age level using paper-and-pencil booklets and others using the digital platform. The simplest bridge study would use just two groups. One group would be tested using paper-and-pencil booklets during the current LTT testing window and the other would be tested using a digital platform during the main-NAEP testing window. This design would permit estimation of the combined effect of changes to both the testing window (current LTT versus main-NAEP) and platform (paper-and-pencil versus digital). A more sophisticated design would employ four groups at ages 13 and 17, tested using each possible combination of testing window and platform. This design would enable separate estimation of the effects of each change, as well as potential interactions between them. A third bridge study design might be a compromise, using just two groups at age 9, tested with paper-and-pencil booklets (i.e., continuing the LTT status quo) and using a digital platform; and three groups each at ages 13 and 17, tested during the current LTT testing window with paper-and-pencil booklets, during the current main-NAEP testing window with paper-and-pencil booklets, and during the current main-NAEP testing window using a digital platform. This three-group design would provide significantly more information than the two-group design while avoiding the need to support schools in fielding digital assessments at different times of the year.

Bridge study timing. The next LTT assessment is now scheduled for fall 2023 through spring 2024. The scheduled main-NAEP assessments closest to this LTT assessment date would be conducted in January-March 2023 and January-March 2025. Historically, bridge studies have coincided with a regularly scheduled assessment data collection. Because these bridge studies have always focused on procedural changes within either main NAEP or the LTT, this complexity in scheduling a bridge study has not arisen before.[40] As classroom use of digital media increases, and as digital testing is more widely adopted for assessment purposes, children's familiarity with the routines of standardized paper-and-pencil testing may decline rapidly. Students who will be tested as 12th graders in 2023 or as 17-year-olds in 2024 are now close to the very beginning of their formal schooling. By 2024, paper-and-pencil standardized tests may

[40] Thanks to Governing Board staff for alerting the author to this concern.

be essentially obsolete. Thus, there is some urgency in scheduling the proposed LTT bridge study well before the next regular LTT assessment is scheduled to occur.

When a bridge study is conducted in conjunction with a regular NAEP data collection, most of the students included in the bridge study, those in the "new procedures" group, are also being tested as part of that regular data collection. Thus, the additional data collection cost is for a (typically) smaller sample of students tested following old procedures. Because the "new procedures" group is typically much larger, the size of "old procedures" groups is a limiting factor on the precision of bridge study findings. It follows that scheduling a bridge study independent of a regular data collection would have implications for both cost and precision. Cost and administrative burden are of course significant considerations, but a stand-alone LTT bridge study conducted as soon as possible, presumably within the next five years or so, might be seriously considered. Findings from such a study would be noisy (due to limited sample size) but might nonetheless be of considerable value in providing some information on LTT trends during the 12-year interval between the most recent LTT assessment in 2011-12 and the next scheduled LTT assessment in 2023-24. (The bridge study might be designed to estimate procedural effects for reporting subgroups as well as the full population, but trend line data points might be reported only for the nation as a whole.)

Redesigned LTT Model

The bridge study just described would enable continued use of existing LTT exercises, already organized into blocks and combined into booklets, as was done for the 2004, 2008, and 2012 LTT assessments, but migrated onto the digital platform and administered during the main-NAEP testing window. Going forward, any minor updates required would be managed in the same way as has been done for the three most recent LTT assessments. Note that during the integrated main-NAEP plus LTT data collection, each student would respond to just one booklet, providing data on either main NAEP or LTT but never both. Thus, this design could be described as employing two separate (although integrated) student samples for main NAEP versus LTT.[41] The goal would be to enable main-NAEP and LTT data collections to occur simultaneously, with students sitting in the same room at the same time, some responding to main-NAEP and others to LTT exercises. The differences would be invisible to respondents.

An option considered and rejected. Once it is envisioned that main-NAEP and LTT data collections might occur at the same time, the possibility might be considered that, rather than having some students respond solely to LTT exercises and others solely to main-NAEP exercises, LTT and main-NAEP exercise blocks might be paired in the same booklets. Such a further integration of main-NAEP and LTT would permit estimation of individual-level correlations between the LTT and main-NAEP score scales. This option was rejected, however, for the following reasons. First, LTT booklets are still configured with three 15-minute exercise blocks, whereas main-NAEP booklets feature two 25-minute blocks. Thus, reconfiguration of LTT blocks would need to be incorporated as another procedural change in the proposed near-term LTT bridge study.[42] Second, even if LTT blocks were reconfigured to the 25-minute format, the "look and feel" of LTT blocks might be quite different from main-NAEP blocks, if only due to use of more innovative exercise formats and better graphics as main-NAEP more fully exploits the affordances of the digital platform. These differences could potentially induce context effects across blocks within booklets, threatening main-NAEP trend lines. Distortions of LTT response data might be

[41] If a stand-alone bridge study were conducted before 2024, this fully integrated sampling and test administration would not occur until later.

[42] For reading, reconfiguration of 15-minute blocks to 25-minute blocks might be difficult due to shorter LTT reading passage lengths and the need to keep all exercises associated with a given passage together.

even worse, as students who have just completed an interesting, colorfully illustrated, and interactive main-NAEP exercise block might show diminished motivation when the next exercise block they encountered called for multiple-choice responses to exercises presented as text with, at most, relatively crude, static line drawings by way of illustration. Third, main-NAEP and LTT booklets include somewhat different contextual (background) questions, which are used to create conditioning variables in the course of estimating NAEP scale score distributions. While there may be reasons to update LTT contextual variables (ideally maintaining unchanged those that define reporting groups), yoking together the main-NAEP and LTT contextual questions would introduce an avoidable constraint. Fourth, this option would raise the problem of how to configure LTT booklets for students not at the modal grade level and therefore not part of the main-NAEP sample. Using different stimulus materials for off-modal-grade versus at-modal-grade LTT respondents could differentially affect the responses of these two subgroups of LTT students, distorting trends and complicating the use of LTT data for any research purposes. The alternative of including main-NAEP blocks in LTT booklets for off-modal-grade students but then not analyzing or using students' responses to the main-NAEP exercises would not only be an expensive waste of time, but might also raise flags in the Office of Management and Budget (OMB) clearance process for the NAEP data collection. These challenges are not insurmountable, but taken together, they militate against an individual-level linkage between main NAEP and the LTT as part of the regular, recurrent NAEP data collections, even after eliminating the barriers of separate testing windows and distinct testing modes (paper-and-pencil versus digital). Such linkage might instead be the subject of a special study at some point.

Combining LTT, Main NAEP, and Bridge Study Data to Support Longitudinal Research

As discussed throughout this paper, various procedural changes in NAEP have been, and will continue to be, unavoidable. Such changes have included updates to content frameworks, exercises, sampling frames, conditioning variables, decision rules and procedures for arriving at racial/ethnic and other demographic classifications, permissible accommodations, and procedures followed in data collection, analysis, and reporting. The potential effects of significant procedural changes are investigated via bridge studies. Whenever possible, small uniform effects are absorbed into scaling constants so that reporting scales are unchanged and trend lines are continuous. When the effects of some change cannot be simply adjusted for, then two sets of results are reported for the year in which changes are adopted.

At the same time, the NAEP program has a long history of efforts to promote greater access and wider use of assessment data by making statistical tools and other kinds of supports available. The ETS proposal in the early 1980s promised that among other improvements, the new design would make available "public USEFUL tapes," not just "public use tapes" (Messick, Beaton, and Lord, 1983, p. 34, capitalization in original). Efforts to make good on that promise included the *NAEP Primer* (Beaton and Gonzalez, 1995) featuring a self-weighting subsample of NAEP data, and an updated *Primer* with data from the 2005 mathematics assessment.[43] More recently, NAEP data have been made more available and secondary analysis has been simplified via the powerful and user-friendly NAEP Data Tool, and most recently, the NAEP Data Explorer accessible via the NCES website.[44]

[43] Available at https://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2011463.
[44] Available at http://nces.ed.gov/nationsreportcard/naepdata.

Following in that same tradition, NCES, probably via NAEP contractors, might exploit bridge study data, main-NAEP and LTT assessment data, and possibly data from one or more small, additional special data collections, as needed, to model hypothetical data collections employing current assessment procedures but conducted at earlier points in time. Each such model would yield a simulated set of individual-level plausible values, which could then be used to project current trend lines backward in time. To the extent possible, such models would incorporate all of the same background variables used for conditioning in the most recent NAEP analyses, enabling flexible use of the simulated plausible value data sets to study and compare the projected performance of various subgroups with minimal bias. The result would be a resource of great value to policy researchers and other social scientists using NAEP trend data to study achievement over time. Such a modeling effort would explicitly acknowledge that the constructs measured by NAEP assessments have evolved, consistent with the vision articulated by the Governing Board (1996; 2002) and also by the Expert Panel on the Future of NAEP (2012). Despite this evolution, the precise constructs defined by successive NAEP frameworks are extremely highly correlated, and so it is meaningful and appropriate to use measurements of one of these distinct constructs as a predictor of another.

As an example, consider the projection of the LTT age 9 reading trend line backward from 2004 to 1999. Currently, reading in 1999 and 2004 can be directly compared, and reading in 2004 and 2008 can be directly compared, but the 1999-2004 comparison is for the LTT under old procedures, including population definitions that implicitly incorporate old accommodation policies, and the 2004-08 comparison is for the LTT under new procedures, including greater inclusion of students with disabilities under more recent accommodation policies. Findings from 1999 and 2008 cannot be compared directly, largely due to these population changes. A backward projection from 2004 to 1999 would yield simulated 1999 data for the more inclusive population, which could be directly compared with LTT assessment results from 2004 and thereafter. Data from the 2004 bridge study could be used to model the effects of the 2004 procedural changes as a function of individual student characteristics, and this model could then be applied to the 1999 data to estimate a new set of plausible values for each 1999 respondent. At the same time, the 1999 sample could be augmented with additional, hypothetical respondents standing in for students excluded in 1999 due to disabilities that would not have disqualified them from participating under the newer testing accommodation policies. Finally, plausible values would be drawn from each student's modeled (hypothetical) posterior distribution. These hypothetical plausible values would have somewhat larger variances than the plausible values actually generated in 1999, reflecting uncertainty due to modeling. These newly estimated, hypothetical 1999 plausible values could then be used to estimate performance distributions on the age 9 LTT reading scale under policies and procedures introduced in 2004, for the more inclusive population as a whole as well as for traditional reporting subgroups.

If such a methodology could be perfected, it might in principle be used to extend current main-NAEP trend lines backward in time to the earliest days of NAEP. The uncertainty in such estimates would be considerable, but that uncertainty could be quantified, and the resulting continuous data series could be of considerable value for research and policy. Of course, some cautions are in order. In addition to quantifying uncertainty, it would be critically important to document, and to the extent possible, to quantify, potential sources of bias. Different interpretations of such extrapolations would entail different assumptions, limiting the kinds of interpretations that could be supported. In particular, some intended inferences might rely on the clearly untenable assumption that extrapolated results quantified historical mastery of current main-NAEP content that was in fact rarely taught in earlier years. It must be emphasized that these backward projections would not replace current main-NAEP and LTT reporting.

They would probably be produced after some significant time delay, and would be intended for research purposes.

Summary and Conclusion

The LTT is a critical component of NAEP, adding substantial value not only historically but right up to the present. As attested by current controversies surrounding state adoptions of the Common Core State Standards, there is an abiding interest on the part of some policymakers, educators, and segments of the public in students' performance on content and skills viewed as simpler and more traditional than those espoused in current curriculum reforms. This is the kind of material tested by the LTT. In addition, as the mean age of children at each grade level gradually increases over time, age-based trends offer important context for interpreting grade-based trends; and some important policy questions have been cited that can only be investigated using age-based, as opposed to grade-based, trend information. Some differences between LTT and main-NAEP data collections have persisted as a consequence of design choices made almost a half-century ago and maintained since then to avoid disrupting trends. Some of these choices, such as paced-tape booklets and "I don't know" answer choices, were eliminated in the 2004 LTT bridge study, but separate testing windows have been maintained.

Careful consideration of the uses and interpretations of the LTT suggests that the most important distinctions between the LTT and main NAEP center on the distinct content assessed and on age-based versus grade-based sampling. Differences in testing windows appear unimportant. In addition, large-scale paper-and-pencil testing is already becoming antiquated, and so LTT migration to a digital platform is a matter of some urgency. Thus, this paper proposes consideration of another LTT bridge study to continue LTT trends with digital testing, concurrent with main-NAEP data collections. This would enable cost savings via integration of main-NAEP and LTT sampling and data collection with essentially no risk to main-NAEP trend lines, preserving the legacy of trend lines reaching back to NAEP's earliest days and supporting continuation of the LTT into the future, as mandated by current legislation. When main NAEP is fully digital, the cost of a separate paper-based LTT data collection will probably be prohibitive. For reasons already discussed, this proposed LTT bridge study should be scheduled as soon as possible.

One final proposal included in this paper sketches an approach to enhancing the utility of both main-NAEP and LTT data for research purposes by projecting recent trend lines backward in time. To accomplish this, bridge study data would be used to model the effects of procedural changes at the individual student level, and the resulting models would then be applied to assessment data from prior years to generate new sets of plausible values, simulating the responses of these historical respondents under future testing conditions. The resulting data sets would be for research only, and would have to be treated with considerable caution. They would certainly not supplant current procedures for NAEP reporting.

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Appendix A
LTT Content Descriptions from *2011-2012 Long-Term Sample Exercise Booklet*[45] pages 8-10

Description of Long-Term Trend Mathematics

Ages 9, 13, and 17

The long-term trend mathematics assessment covers the following content topics: numbers and numeration; measurement; shape, size, and position; probability and statistics; and variables and relationships. Each test booklet consists of three content blocks of 15 minutes each.

- *Numbers and Numeration*: These exercises deal with the ways numbers are used, processed, or written. Knowledge and understanding of numeration and number concepts are assessed for whole numbers, common fractions, decimal fractions, integers, and percents. Considerable emphasis is placed on operations. Number properties and order relations are also included.

- *Measurement*: These exercises cover appropriate units; equivalence relations; instrument reading; length, weight, capacity, time, temperature, perimeter, area, and volume; nonstandard units; and precision and interpolation. A substantial number of the measurement exercises require the use and understanding of metric units.

- *Shape, Size, and Position*: These exercises measure objectives related to school geometry and concern plane and solid shapes, congruence, similarity, properties of triangles, properties of quadrilaterals, constructions, sections of solids, basic theorems and relationships, and rotations and symmetry.

- *Probability and Statistics*: These exercises assess collecting data; organizing data with tables, charts, and graphs; interpreting and analyzing data; drawing inferences; making generalizations; using basic statistics; predicting outcomes and determining combinations.

- *Variables and Relationships*: These exercises deal with the recognition of facts, definitions, and symbols of algebra; the solution of equations and inequalities; the use of variables to represent problem situations and elements of a number system; the evaluation and interpretation of functions and formulas; the graphing of points and lines in a coordinate system; and the use of exponential and trigonometric functions, and logic. Most of these exercises are at the 17-year-old level, at which students have had the opportunity to study algebra.

[45] See http://nces.ed.gov/nationsreportcard/subject/_commonobjects/pdf/demo_booklet/2011_12_sqb_ltt.pdf. "Demonstration Booklets" from the 2003-2004 and 2007-2008 LTT assessments contain nearly identical text, although the values in the "Target Percentages by Age Level" for the mathematics LTT differ slightly between the earlier booklets and the booklet from 2011-2012, and the earlier booklets do not give any percentage breakdowns for reading (see https://nces.ed.gov/nationsreportcard/pdf/demo_booklet/ltt_demo_bklet.pdf and https://nces.ed.gov/nationsreportcard/pdf/demo_booklet/08-sq-ltt.pdf).

For the three age levels assessed—9, 13, and 17—the percentage of test questions from each content topic is distributed as follows:

Target Percentages by Age Level

	Age 9	Age 13	Age 17
Numbers and numeration	50%	50%	44%
Measurement	19%	19%	12.5%
Shape, size, and position	12.5%	12.5%	12.5%
Probability and statistics	6%	6%	6%
Variables and relationships	12.5%	12.5%	25%

The long-term trend mathematics assessment includes the following process domains: mathematical knowledge, mathematical skill, mathematical understanding, and mathematical application.

- *Mathematical Knowledge*: Mathematical knowledge refers to the recall and recognition of mathematical ideas expressed in words, symbols, or figures. Mathematical knowledge relies, for the most part, on memory processes. It does not ordinarily require more complex mental processes. Exercises that assess mathematical knowledge require that a student recall or recognize one or more items of information. An example of an exercise involving recall would be one that asks for a multiplication fact, such as the product of five and two.

- *Mathematical Skill*: These exercises require the performance of specified tasks, such as making measurements, multiplying two fractions, performing mental computations, graphing a linear equation, or reading a table.

- *Mathematical Understanding*: Exercises that assess mathematical understanding require that a student provide an explanation, an illustration for one or more items of knowledge, or the transformation of knowledge. They do not require the application of that knowledge to the solution of a problem. An example of an exercise involving understanding is one that asks why a certain graph is not the graph of a function.

- *Mathematical Application*: Mathematical application and problem solving refer to the use of mathematical knowledge, skill, and understanding in solving both routine and nonroutine problems. Exercises that assess mathematical application and problem solving require a sequence of processes that relate to the formulation, solution, and interpretation of problems. The processes may include recalling and recording knowledge, selecting and carrying out algorithms, making and testing conjectures, and evaluating arguments and results. Exercises assessing mathematical application may vary from routine textbook problems to exercises dealing with mathematical arguments.

Description of Long-Term Trend Reading

Ages 9, 13, and 17

The long-term trend reading assessment contains a range of reading materials, from simple narrative passages to complex articles on specialized topics. The selections include brief stories, poems, and passages from textbooks and other age-appropriate reading material. Students' comprehension of these materials is assessed with both multiple-choice questions and constructed-response questions in which students are asked to provide a written response. In the long-term trend reading assessment, students are given selections in expository reading, narrative reading, and document reading. Each test booklet consists of three content blocks of 15 minutes each.[46]

The expository reading selections in the assessment consist of passages ranging from 250 words to 500 words at age 9 or to 800 words at age 17 and short paragraphs of 50 to 150 words at all ages. Students read a passage, then answer multiple-choice or constructed-response questions about the passage. The percentage of questions in the assessment allocated to expository reading varies, by age and by block, from 54 percent to 61 percent.

Similarly, the narrative reading selections in the assessment consist of passages ranging from 250 words to 500 words at age 9 or to 800 words at age 17 and short paragraphs of 50 to 150 words at all ages. Students read a passage, then answer multiple-choice or constructed-response questions about the passage. The narrative reading selections also include poetry passages of 50 to 150 words, followed by multiple-choice and constructed-response questions. The percentage of questions in the assessment allocated to narrative reading varies, by age and by block, from 14 percent to 23 percent.

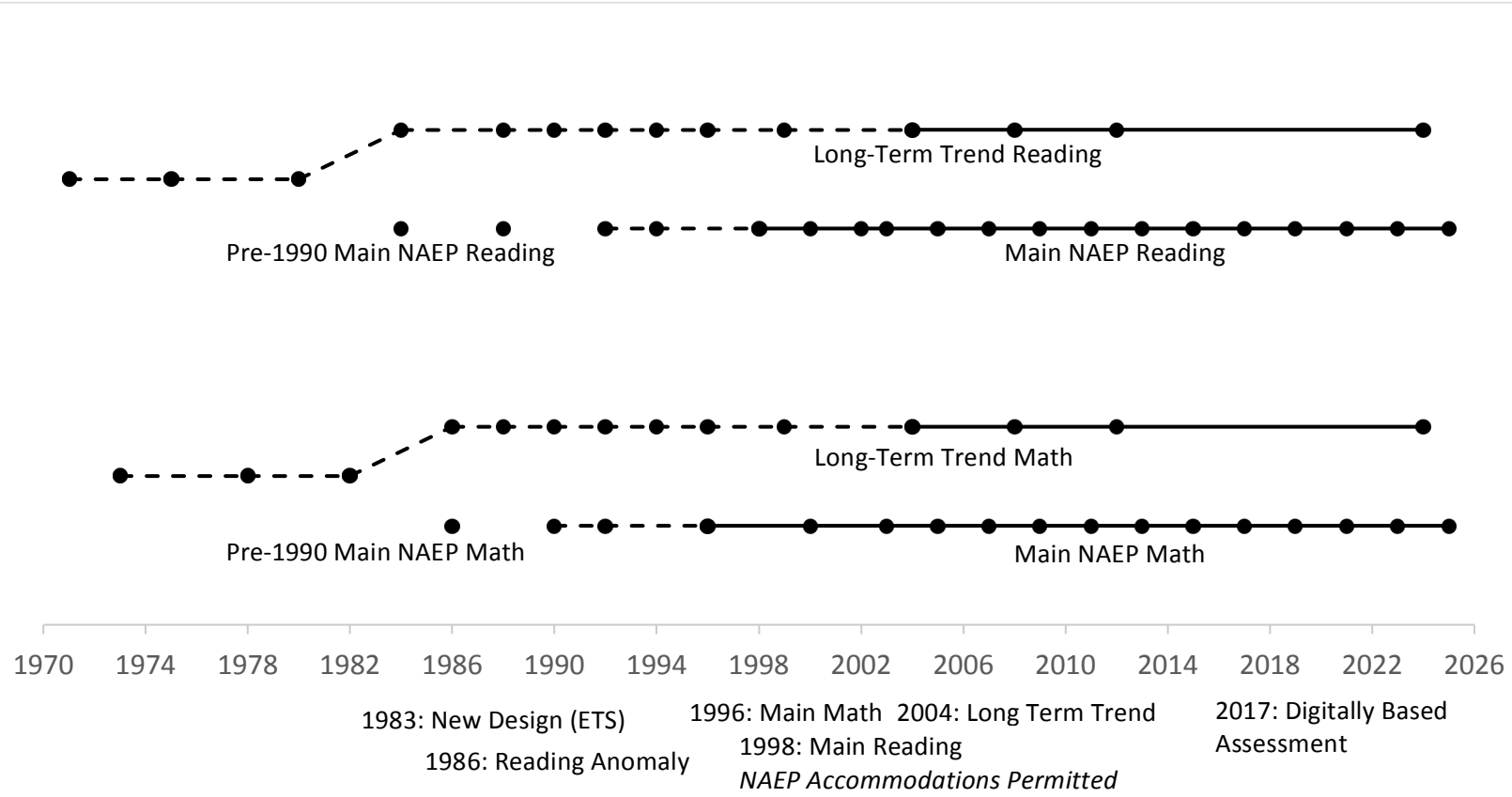
The document reading selections in the assessment consist of materials that represent real-life activities, such as a train schedule or a sale coupon. The percentage of questions in the assessment allocated to document reading varies, by age and by block, from 17 percent to 24 percent.

Percentages of Items by Text Type, Item Format, (sic) **and Age Level**

Text Type	Age 9	Age 13	Age 17
Expository	66%	59%	70%
Narrative	24%	18%	13%
Document and other	10%	23%	17%

[46] This description, taken directly from the *2011-2012 Long-Term Sample Exercise Booklet*, omits any further mention of the specific reading skills assessed by the LTT, nor does it note that most LTT reading passages were written specifically for NAEP. This contrasts with the current practice for main-NAEP of relying exclusively on authentic texts.

Figure 1: Timelines for Long-Term Trend (LTT) and Main NAEP, showing past and future anticipated trend line linkages.



Notes: Dots represent assessments. Connecting lines (either dashed or solid) indicate assessments reported on a common scale. Splits in lines in mid-1980s show beginnings of Long-Term Trends. Changes from dashed to solid lines show where trend lines were re-started (with bridge studies). Some assessments shown included only one or two age or grade levels (see https://nces.ed.gov/nationsreportcard/about/assessmentsched.asp). Schedule shown past 2017 is unofficial and subject to change.

Why Continue An Old Assessment?

A paper on the NAEP Long-Term Trend Assessments prepared for
the National Assessment Governing Board
Jack Jennings
February 13, 2017

In this age of student testing mania, a strong justification should be required to initiate or continue any assessment. Edward Haertel's excellent paper for the National Assessment Governing Board (Governing Board) makes such a case for the Long-Term Trend (LTT). My paper supplements Dr. Haertel's, emphasizing certain of his points and adding others from my experiences with the National Assessment of Educational Progress (NAEP).

I am not an expert in psychometrics; rather, my career has been in the policy arena. While working for the U.S. House of Representatives from 1967 to 1994, I helped write education laws, including those affecting NAEP. From 1995 to 2012, I monitored NAEP as part of my responsibilities heading the Center on Education Policy. Also relevant are my nine years of service on the Board of Trustees of the Educational Testing Service, which has the principal contract dealing with NAEP. These experiences have shaped my views of NAEP.

My position is that the LTT is irreplaceable in understanding students' academic achievement in the United States. The Governing Board should thus reverse its decisions resulting in a 12-year hiatus in the administration of that assessment. Such a long break in data collection undermines the usefulness of the LTT.

The arguments to support the LTT include the Governing Board's legal obligation to maintain it, as well as prudence in retaining the only continuous measurement since the early 1970s of what students *actually* know and are able to do, while what students *should* know and be able to do has been measured from the early 1990s by the main NAEP.[i] Also noteworthy is the LTT's relevance in policy-making and the additional opportunities it affords to implement the Governing Board's new strategic vision.

I commend the Governing Board for organizing this review of its decision regarding the Long-Term Trend. The Governing Board is setting an excellent example for prudent policy-making by inviting a diverse set of people to critique its actions.

The Legal Obligation to Continue the LTT

A basic duty.

"The Commissioner for Education Statistics shall, with the advice of the Assessment Board… continue to conduct the trend assessment of academic achievement at ages 9, 13, and 17 for the purpose of maintaining data on long-term trends in reading and mathematics." The Governing

Board is therefore legally bound to continue the LTT, but not required to administer the assessment on any particular schedule.[ii]

The decisions resulting in a 12-year gap between administrations of LTT, however, indirectly frustrates that clear legal obligation to "continue to conduct the trend assessment..." The letter of the law is being carried out, but not its spirit.

When the Governing Board made these decisions, scarcity of funds was cited. Money, however, was found for a Technology and Engineering Literacy Assessment and other projects.

Over the years, the Governing Board's principal responsibility has been to oversee the assessment of the reading and mathematics achievement of American students through the LTT and the main NAEP. Other projects should not be funded unless that basic responsibility has been carried out.

Reasons for this particular responsibility.

The Governing Board's obligation to continue the LTT was imposed primarily because of the value of such long-term trends. An additional reason was concern about the development and use of the achievement levels in the main NAEP. A short review of NAEP's history will help to explain the latter issue.

In the 1988 education amendments, the Governing Board was created and charged with identifying appropriate achievement goals. The Governing Board established three: *Basic*, *Proficient*, and *Advanced*. An independent evaluation of the "trial assessments," as the new tests were known, was to be undertaken by a nationally recognized organization to assess the feasibility and validity of the assessments and the fairness and accuracy of the resulting data.[iii]

In 1990, the Governing Board hired a team of evaluators to study the process of comparing student performance using the three levels. This group was fired a year later after its draft report concluded that the process "must be viewed as insufficiently tested and validated, politically dominated, and of questionable credibility."[iv] The Governing Board disputed the assertion that the dismissal was due to these conclusions.

In 1993, the National Academy of Education (NAE) and the U.S. General Accounting Office reviewed the student performance standards concluding that they did not meet technical expectations and should not be used as the primary means for reporting NAEP.[v] The following year, a law was enacted requiring the Governing Board's performance levels to be labelled "on a developmental basis," until such time as an independent review by an organization such as the NAE or the National Academy of Sciences (NAS) found them to be reasonable, valid, and informative to the public.[vi]

In 1998, another congressionally mandated evaluation by the NAS concluded that NAEP's procedures for setting cut-scores was fundamentally flawed because it rested on "informal judgment" rather than a "highly objective process," and thus produced some unreasonable results. Highly critical of NAEP's achievement levels, the Academy urged caution in their use.[vii]

In 2001, the *No Child Left Behind Act* (NCLB), while requiring states to participate in NAEP, continued the achievement levels on a "trial basis." The law further required that the results from

the newly mandated state tests be reported using the same format as NAEP's three achievement levels. An important point, though, is that *NCLB* allowed states to have their own definitions of the level of achievement for each level.[viii] In other words, the labels were the same, but the definitions of achievement could—and did—differ by state from the national assessment.

In 2005, U.S. Secretary of Education Margaret Spellings urged reporters to compare state proficiency levels under *NCLB* to NAEP's *Basic* achievement level. Her statement was in response to the confusion resulting from the use of the same three titles for measuring student achievement in NAEP and in the *NCLB*-required state tests. Some states defined proficient on their tests to be higher than what was considered *Proficient* on NAEP, but most states' definitions were less demanding, resulting in a muddle. Spellings's view implied that NAEP's *Proficient* level was ambitious, more than what would be expected of most students.[ix]

In 2008, the Center for Public Education of the National School Boards Association sought to clarify the issue using Governing Board and U.S. Department of Education resources. The proficient level defined by states for their tests meant meeting grade-level expectations. In contrast, NAEP's *Proficient* level was an *aspirational goal* for American students, not grade-level achievement.[x]

These explanations were helpful; but when NAEP results were released, the news media continued to emphasize the percentages of students meeting the *Proficient* level, not those meeting the *Basic* level. Since *NCLB* had set the national goal of all students being proficient by 2012, proficiency seemed the objective—rather than meeting a basic level of academic performance.

In 2016, Campbell Brown, a former CNN anchor starting her own education reform group, said that two out of three eighth graders could not read or do mathematics at grade level. When challenged by Tom Loveless of the Brookings Institution about the accuracy of that statement, her response identified NAEP as her source. Loveless countered that *Proficient* in NAEP meant mastery over challenging subject matter, not doing mathematics or reading at grade level. She retorted: "But any reasonable person or parent can rightly assume that if their child is not reading at grade level, then their child is not proficient."[xi]

Also last year, another NAS report was issued on the NAEP achievement levels for reading and mathematics.[xii] The U.S. Department of Education had commissioned this review because these levels, more than two decades after their creation, were still labeled "trial." That designation resulted from the lack of an independent evaluation determining these levels to be "reasonable, reliable, valid, and informative to the public," as required by the 1994 law.

The Academy concluded that some aspects of the original process of determining the levels were positive. But since then, problems persisted with the levels' validity, lack of interpretive guidance for the results, and misalignment of the assessments. Hope was offered, though, that if certain steps were taken, such as better alignment "among the frameworks, the item pools, the achievement-level descriptors, and the cut scores," the levels could be considered as meeting the legislated standards.

This short history shows two major tensions. First, student achievement levels were adopted as a means of making more understandable NAEP student achievement data. Yet, 25 years after their creation, it is still a challenge to convey to the public and to the news media what NAEP has found. Second, independent expert criticisms during the same quarter-century have persistently found that the levels are lacking in certain key respects. Thus, they are still on "trial."

In the late 1980s, when these achievements levels were authorized by law, Congress realized that this process was something new and would be difficult to get right. The LTT, therefore, was continued as a *safeguard* so that there would be some way to measure achievement while the new process was fought over and developed. Since the National Academy of Sciences in last year's report still sees problems with the levels, we have not yet reached the end-stage of that development. Thus, the safeguard of the LTT is still needed.

Also important to note in continuing the LTT is the difference in purpose between the LTT and the main NAEP as it is usually reported in the news. As the latest NAS report states:

> Originally, NAEP was designed to measure and report what U.S. students *actually* know and are able to do. However, the achievement levels were designed to lay out what U.S. students *should* know and be able to do. That is, the adoption of achievement levels added an extra layer of reporting to reflect the nation's aspirations for students.

It is true that since the early 1990s the main NAEP has also reported on what students have actually learned. But, the news media concentrate on the achievement levels in their reporting of NAEP results. In fact, the main NAEP is defined by these achievement levels which were created to be aspirational or something that would motivate students to strive to do better. That purpose is quite different from reporting on what students have actually attained without regard to what they should have attained.

Relevance

Congress had its reasons for imposing the legal obligation on the Governing Board to continue the LTT. A major benefit from that decision is LTT's relevance in making policy.

The last few years have been a time of frustration for many state education leaders. Bush's *NCLB* and Obama's Race to the Top were seen as federal mandates, disrespectful of state and local control of education.

Recently, the National Conference of State Legislators (NCSL) decided to take matters into its own hands. On a bipartisan basis, leading legislators set out to determine how best the states themselves could improve elementary and secondary education. They began by studying NAEP's LTT and several international studies. From this review, the group concluded that American students are struggling to meet relatively low expectations.

No Time to Lose,[xiii] NCSL's first report from this project, prominently displays at the beginning of its analysis a table of LTT's data on student achievement. The report proceeds to recommend major systemic changes in American schools.

This attention to the LTT demonstrates its continuing usefulness to policymakers. Very appropriately, the Governing Board describes that assessment "as the largest, nationally representative, continuing evaluation of the condition of education in the United States." Other long-term student data sets have major limitations, for example, SAT and ACT data are not representative samples because students choose to take those tests. From its beginnings in the 1960s, NAEP has presented a psychometrically sound picture of student achievement in the elementary and secondary schools.

Why wouldn't we want to continue such a valuable source, especially when it informs policy-making?

Lessons in assessment issues

In November 2016, the Governing Board adopted a Strategic Vision to facilitate the greater awareness and better use of NAEP.[xiv] The LTT presents a perfect opportunity to fulfill that Strategic Vision by explaining trends in the achievement gap among various populations, and demonstrating the effects on test scores of changing demographics.

Too often, it seems a simple story based on the overall results is told in the news media and not a more complex tale considering major changes in the demography of the student test-takers. This complexity can especially be seen in the uniqueness of the LTT's administration over 45 years.

For instance, the news media will report that no significant change occurs in either reading or mathematics for all tested 17-year-olds from the early 1970s to the current decade. But, quite a different story is shown by looking at the scores of the three major subgroups composing almost all of the tested students. Over four decades, the achievement gap decreased: black and Hispanic students made academic progress while the scores of white students also increased. Everyone was a winner.[xv]

In reading the more recent releases of NAEP results, I notice that there is more emphasis on these disaggregated results and the reasons for variances from the overall results. I would like to thank the Governing Board and the National Center for Education Statistics[xvi] for those efforts to explain more fully what the test scores show.

I would go further and urge that when NAEP results are released, the overall results and the disaggregated results should be presented together on the same page. The full story is missed too often by the news media if one concentrates on the overall trends.

Since NAEP began 45 years ago, the demographic changes have been so dramatic that it is necessary to explain them at each opportunity. For example, 13-year-old white students were 80 percent of NAEP-tested students in 1978, but declined to 56 percent in 2012. Black students increased from 13 to 15 percent, while Hispanic students grew dramatically from 6 to 21 percent.[xvii]

White students as a group generally score highest of the three groups, but their percentage of all students has dramatically declined. Black students are performing better than in years past but not as high as white students, while their percentage of all students has grown. Hispanic students

are also scoring higher but again not as high as white students, while their percentage of all students has dramatically increased.

So, the scores of black students and Hispanic students went up as did their proportion of the students tested; but, the increased scores were not enough to make up for fewer white students who scored higher. The result is no general gain in test scores while below the surface there is a gain for each major subgroup.

This so-called "Simpson's Paradox" is difficult to explain to the news media and thereby to the public. So, every opportunity should be seized to do so. This phenomenon appears in both the LTT and the main NAEP, but the long-term administration of the former makes the changes more dramatic.

Why two assessments and not one?

Even given all those reasons for continuing the LTT, a nagging question is: why should there be two assessments—the LTT and the Main NAEP? Could one assessment do it all?

As Dr. Haertel points out, LTT's content is simpler and more traditional than that espoused in current curriculum reforms. The LTT assessments address "a fairly low-level traditional subset of contemporary curricular objectives." In contrast, the main NAEP "evolves in response to changing curricular priorities and expectations for schooling outcomes…"

The LTT can serve as an "anchor," as described by Dr. Haertel, since "the LTT has measured the same content for decades." Even if the content leans towards basic skills, whether students have mastered those skills and knowledge should be known.

The second point is that LTT tests by age level, and main NAEP by grade level. As Dr. Haertel points out, contrasts between age-based and grade-based gaps and trends can be useful because children are starting school at a later chronological age and students of various racial and ethnic groups are retained in grades at different rates.

Lastly, cost is a concern in retaining two assessments. Dr. Haertel has presented an option reducing costs while retaining the integrity of both sets of tests. I do not know enough about the technicalities of his proposal to endorse it fully; but if it retains the LTT as a valid, dependable assessment, I would hope that the Governing Board would seriously consider his ideas.

Conclusion

In sum, the National Assessment Governing Board should maintain the integrity and usefulness of the LTT, in spirit as well as in form. To accomplish this, the Long-Term Trend should be administered every few years.

Other advantages that would flow from that policy are that the LTT would continue to be influential in policy-making, and the Governing Board's new Strategic Vision could be further implemented.

Lastly, creativity in assessment ought to be encouraged. If Dr. Haertel's proposal for the LTT can maintain the integrity and usefulness of that assessment, then the Governing Board should consider its adoption.

From my experiences, two aspects of the LTT are the essence of what should be retained. First, the length of time is unique. LTT starts in the early 1970s while the main NAEP originates in the early 1990s; and those two decades should not be lost. The trend lines should be maintained as far back as possible. Second, what students have been tested on in the LTT over these 45 years should be retained as much as possible. As I understand it, that is necessary to maintain the integrity of the trend lines in that assessment.

Let me end as I started. I am not a psychometrician, I am a mere lawyer who has been involved in policy. If creative assessment experts find some way to retain the essence of the LTT in a simpler way than we have now, that would be to the good. But, we must retain that essence.

May I again commend the Governing Board for sponsoring this review of its decisions about the LTT. This is a very thoughtful way to proceed on making wise policies.

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[i] The Main NAEP has also measured what students have actually attained since the early 1990s.

[ii] P.L. 107-279. Title III, the *National Assessment of Educational Progress Authorization Act.*

[iii] P.L. 100-297, the *Augustus F. Hawkins-Robert T. Stafford Elementary and Secondary School Improvement Amendments of 1988,* Title III.

[iv] Robert Rothman, "NAEP Board Fires Researchers Critical of Standards Process," *Education Week,* September 4, 1991.

[v] Mary Lyn Bourque, "A History of NAEP Achievement Levels: Issues, Implementation, and Impact. 1989-2009," Paper Commissioned for the 20th Anniversary of the National Assessment Governing Board, March, 2009.

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[xii] Christopher Edley Jr., Judith A. Koening, *Evaluation of the Achievement Levels for Mathematics and Reading on the National Assessment of Educational Progress*, National Academy of Sciences, November 2016.

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[xiv] __ *Strategic Vision*, National Assessment Governing Board, November 18, 2016.

[xv] National Assessment of Educational Progress, 2012 Long-term: Summary of Major Findings, Institute of Education Sciences, National Center for Education Statistics, U.S. Department of Education. Data downloaded August 14, 2014 from http:/www.nationsreportcard.gov/ltt_2012/summary.aspx.

[xvi] The National Center for Education Statistics of the U.S. Department of Education is responsible for writing and releasing the reports on the National Assessment of Educational Progress.

[xvii] National Assessment of Educational Progress, 2012 Long-term: Summary of Major Findings, Institute of Education Sciences, National Center for Education Statistics, U.S. Department of Education. Data downloaded August 14, 2014, from http:/www.nationsreportcard.gov/ltt_2012/summary.aspx.

Is It Time to Retire Long-Term Trend?

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February 12, 2017

This is a reaction paper to Dr. Edward Haertel's white paper prepared for the National Assessment Governing Board (the Governing Board) on the "Future of NAEP Long Term Trend Assessments," dated December 9, 2016. The reaction paper will focus on arguments against keeping the National Assessment of Educational Progress (NAEP) Long-Term Trend (LTT) assessments. The thoughts expressed in the paper are solely the opinions of the author and not a reflection or representation of any official position of the North Carolina Department of Public Instruction or the North Carolina State Board of Education.

The comprehensiveness of Dr. Haertel's white paper is outstanding and he offers an engaging historical perspective covering the Long-Term Trend NAEP's roots and evolution, changes over time, challenges, and issues confronting the program since its beginning in the late 1960s.

As Dr. Haertel states:

> The focus of this white paper is on the LTT assessments in reading and mathematics, as well as their relation to the main NAEP assessments in these same subject areas. It is intended as a starting point for a broad discussion of the LTT assessments, offering an overview of issues and options that might be explored in greater depth in future papers and symposia. Specifically, this white paper offers a brief history of the LTT and then addresses the following questions:
> • What are some arguments for and against continuing the LTT component of NAEP in essentially its current form versus dropping it altogether?
> • How might the LTT component instead be integrated (or blended) with main NAEP assessments?
> • How might historical LTT data, main NAEP data, and bridge study data be integrated to make NAEP more useful for longitudinal research? (p.2)

Why have NAEP? It is the law, and the U.S. Congress and many others want to know how students are performing in the United States. The author in this paper will be focusing on the benefits of "main NAEP," which Haertel explains is what today refers to as the NAEP assessments from 1990 to the present that are based on assessment frameworks developed by the Governing Board and for which new scales and trend lines started. Results for main NAEP are available going back to 1990 for mathematics at the national level in grades 4, 8, and 12, and 1992 for reading at the national level in grades 4, 8, and 12, contrasted with the LTT (for which reporting results are available going back to 1973 in mathematics and 1971 in reading for 9-, 13-, and 17-year-old students).

National and state results. The main NAEP, in addition to reporting results at the national level, also reports results for all 50 states and the District of Columbia in grades 4 and 8. The state-by-state reporting of main NAEP allows each state to compare its performance with other states *as well as* the nation. Prior to the state-by-state reporting of main NAEP results, there was no way for states to benchmark their performance against other states (unless the states used the same assessments) and the nation. Even though each state and the District of Columbia are required to have assessment systems that can generate assessment results, it is main NAEP that provides that benchmarking capability for all states and it has done so for more than 25 years. This seems to the author to be a sufficient number of years to show trend analyses over time. This benchmarking capability, the author believes, is what state-level policymakers need to determine how well the students in their states are performing in grades 4 and 8 in reading and mathematics and what the U.S. Congress and other national policymakers need as well when looking at the national results.

Choices and recommendation? In essence, there are three choices for the Governing Board and the Commissioner of the National Center for Education Statistics (NCES) regarding the LTT: (1) continue with the LTT – it is in the federal law; (2) figure out a way to combine it in some way with main NAEP in the future; or (3) convince the U.S. Congress to remove the LTT requirement from the current legislation or future reauthorizing legislation. After reading Dr. Haertel's paper and reviewing other reports, particularly Lawrence C. Stedman's *The Long Term-Trend Assessment: A Review of Its Transformation, Use and Findings* (March 2009), this author believes that the last choice is the best. As a tweet, the author's recommendation in 140 characters or less would be "Long-Term Trend… dump it!"

In the current political climate, if the Governing Board makes the recommendation to discontinue the LTT and focus all of its energies on main NAEP (and if the NCES Commissioner of Education Statistics agrees with the recommendation), the author does not believe that the U.S. Congress will make its ultimate decision based on many of the arguments included in Dr. Haertel's paper. The author believes that the decision will be based on reasons that benefit the nation *and* the states and that is the perspective presented below.

Differences between the LTT and main NAEP. The author will not describe the differences between the two types of assessments in this paper, but NCES has a very concise comparison at https://nces.ed.gov/nationsreportcard/about/ltt_main_diff.aspx.

Who really cares about Long-Term Trend? The author contends that the stakeholder group most interested in the LTT is researchers. The author has never been in a meeting with a group of educators (outside of the Governing Board-related meetings) and heard anyone ask, "When are the results from the LTT being released? I can't wait to see how the nation is doing compared to where the nation was in the early 1970s." I am sure someone has asked that question but it is probably researchers who make the statement that they "can't wait to get access to the LTT data to run some analyses." This is not surprising because state-level educators and policymakers do not glean much information from the LTT results compared

with the benefits they receive from the national main NAEP results and the state-level main NAEP results (or LEA-level results for the 27 participating school districts in the Trial Urban District Assessments [TUDA]).

Benefits of main NAEP. Now, let us return to main NAEP. It is the state-by-state reporting of results at grades 4 and 8 that captures state-level policymakers' interest in how their state is doing in education. The U.S. Congress and others also benefit from main NAEP in that one can look at results at the national level in grades 4, 8, and 12 and compare student performance back to the early 1990s. Yes, that is about 20 years later than the LTT, but once one reviews all of the changes that occurred in the LTT during the time period of 1970 to 1990 and beyond, there are too many issues described by Haertel and Stedman to make the claim that one is truly comparing apples-to-apples with the reporting of results from the LTT during those 20 years and even beyond. Haertel states, "The assessment program envisioned by NAEP's founders looked very different from NAEP today." (p. 3) He goes on to describe numerous changes including, among others, how lists of objectives were initially developed, and how reporting would not be in terms of test scores but "in terms of estimated proportions of populations and subpopulations able to answer each exercise correctly." He then includes the following paragraph:

> Almost from NAEP's very beginning, it had proven *necessary to modify* one after another of its original guiding principles. Among other *compromises*, inclusion of children with severe disabilities proved *prohibitively expensive*. Contractors submitted fewer very easy items and a greater proportion of multiple-choice questions than had been specified. Within a few years, *budgetary constraints* forced discontinuation of testing for out-of-school 17-year-olds and of young adults (Jones, 1996), although 16- to 25-year-olds were assessed under a separate grant in a 1985 "Young Adult Literacy Study." Testing in areas relying most heavily on performance assessment, including art and music, also was *judged too expensive to maintain*. The content areas of reading and literature were combined into one in 1979-80. (p. 3-4, emphasis added)

It is very clear in looking at the words in italics (*modify, compromise, prohibitively expensive, budgetary constraints, too expensive*) that many things have changed with the program and that will continue in the future. Haertel, later in his paper, makes the following statement:

> Further significant changes loom as main NAEP continues the transition to a digital platform in 2017. These changes might be taken to imply that the LTT is increasingly irrelevant, or that the LTT is more important than ever. Regardless, the LTT assessment for 2016 has been twice postponed, first to 2020 and then to 2024. The LTT stands at a critical juncture. Its future is unclear. (p. 20)

Part of the reason why the author believes that the LTT should be discontinued, and that the current legislation that authorizes it should be amended to remove references to the LTT, is that the U.S. Congress also mandates (initially through the No Child Left Behind [NCLB] Act of

2001 and now through the Every Student Succeeds Act [ESSA]) of 2015) that states and school districts must participate in main NAEP assessments in grades 4 and 8 and shall report NAEP results for the respective states on the state-level and school district-level report cards which must be made widely accessible on the respective state and local school district websites. This emphasis by the U.S. Congress on reporting main NAEP confirms to the author that it is main NAEP that warrants more attention than the LTT.

Haertel's arguments against maintaining LTT. Haertel makes the following arguments:

> The principal arguments against maintaining the LTT in its current form are that it is expensive, that maintaining two trends is confusing, that performance on outdated content is no longer of interest to policymakers or other stakeholders, and that a range of changes in schooling, in assessment technology, and in society at large are rendering it irrelevant and possibly invalid. (p. 23)

Then Haertel addresses all four arguments. Regarding cost concerns, he states:

> It is difficult to pursue this argument any further here, because that would require delving into the specifics of costs for the LTT and for competing NAEP priorities and then weighing these against perceived benefits, all within the constraints of historical commitments and statutory requirements. (p. 24)

The author supports Haertel's cost concern argument but believes that members of the Governing Board also support other priorities over the LTT and that is why the Governing Board has twice delayed the LTT administrations from the assessment schedule. Haertel then states that the argument that having two trend lines is confusing "seems weak" and that a related argument about redundancies between the LTT and main NAEP "also seems weak." (p. 26) However, the author agrees with Haertel on his statement that two trend lines being confusing is weak but the author still contends that the LTT should be discontinued in its current format and that doing bridge studies to determine if there are ways to combine the LTT with main NAEP should not be pursued by the Governing Board and NCES. In regard to Haertel's argument about outdated content not being a good argument against maintaining the LTT, the author disagrees. Thinking that LTT's "consistency" is going to be an arbitrator of changing curricular initiatives (like the Common Core State Standards [CCSS]) over the years seems like wishful thinking. If anything, the country seems to be moving away from anything that references the CCSS and the number of states participating in the assessment consortia is much lower than would have been predicted several years ago. Additionally, much of the confusion over the CCSS and the assessment consortia are the results of misinformation and misunderstandings. Finally, Haertel's reflection on the changes in schooling, technology, and society being used as an argument against maintaining the LTT will "require more careful consideration" (p. 25) is correct but the author believes that the value of LTT is diminished in light of the changes he references.

Stedman, in his paper, examines several pros and cons for keeping the LTT. He starts his "Recommendations for the Future" section with the following statements which align with the author's arguments:

> Overall, therefore, there is a compelling case for dropping the trend assessment and relying on the main assessment to generate trends. The dual-testing system is expensive and confusing. The main assessment already provides useful long-term trends. It provides greater coverage of the curriculum, more authentic testing, and is better grounded in contemporary pedagogy. (p.30)

The Governing Board and new directions. The Governing Board does an excellent job in carrying out its congressional mandates and, during the last decade, the Governing Board branched out and worked on the development of a new assessment called *Technology and Engineering Literacy* (TEL) which was administered for the first time to eighth graders in 2014. The expectation of the Governing Board is that it will be administered to 4th, 8th, and 12th graders in the future "if funding permits." In response to the question, "How does this new assessment gauge levels of technology and engineering literacy?", the answer in the frequently asked questions document is as follows:

> An important and innovative design feature of the TEL assessment is its use of scenario-based tasks. These multimedia simulations use videos and interactive graphics to set up realistic situations. Then, students are asked a series of questions to demonstrate their knowledge and skills to solve problems within this practical context. For example, one TEL scenario-based task requires students to investigate why the well in a remote village is not working and how it can be fixed. In another, students are asked to troubleshoot and fix the habitat for a classroom iguana. (https://www.nagb.org/content/nagb/assets/documents/newsroom/naep-releases/naep-tel-webcast-may-17/naep-tel-faq-final.pdf)

The author believes that including scenario-based tasks in assessments like the TEL assessment (and previously to a lesser extent in science assessments since 2009) is a great service to the states in showing the benefits of using such item types. It is through the research studies that the Governing Board commissions for these new endeavors that states become the recipients of the knowledge generated by them. Also, anecdotal feedback from students taking these scenario-based tasks has been very positive. Students actually enjoyed taking the assessment! Additional information on scenario-based assessments can be found at https://www.nagb.org/content/nagb/assets/documents/newsroom/naep-releases/naep-tel-webcast-may-17/naep-tel-scenario-based-one-pager.pdf .

Another example of the Governing Board venturing in a new direction was whether it was possible to provide information from the main NAEP 12th grade assessments regarding academic preparedness of students for college, career, or the military. This resulted in over 30 studies undertaken to determine if the research findings would support reporting on the

academic preparedness for success in entry-level college credit-bearing courses, preparedness for success in entry-level job training programs, or preparedness for success in entering the military. The end result of the studies was the decision by the Governing Board to report only on academic preparedness for entry-level college credit-bearing courses but not on the job-training readiness or military readiness. Studies regarding the military were not pursued because the necessary approvals could not be secured for the studies. Regardless, the diligence on the part of the Governing Board to provide more relevance to the interpretation of main NAEP 12th grade test scores is noteworthy. The author believes that the Governing Board's decision to pursue these new initiatives provides more information of more value to policymakers than the continuance of expending resources on LTT that provides limited information to policymakers that cannot be determined by main NAEP (with the exception of the time span differences between LTT and main NAEP that has already been discussed).

What about merging the LTT with the main NAEP? While the author is only supporting the discontinuation of the LTT, the Governing Board also has the option to pursue research into the feasibility of merging the LTT with main NAEP. It seems to the author that there are so many issues with pursuing that possibility (age-based versus grade-based assessments, differing time limits for the assessments, paper and pencil versus computer-based assessments, to name a few) that there will be an increase in the number of bridge studies required to determine the feasibility. Bridge studies are usually required to confirm whether trends can be continued or how to make adjustments if there are significant differences in outcomes due to changes in the assessments or the administration procedures. Merging the LTT with main NAEP or continuing with the LTT in the future will only add to the number of new bridge studies required, especially in light of the Governing Board's and the Commissioner of Education Statistics' decision to move to all digital-based assessments starting in 2017, which the author supports and believes is the right thing to do. All of these bridge studies will take time and resources including additional students being tested in an environment where demands for fewer assessments are being voiced nationwide and the bridge studies will result in additional burdens on the participating schools and a loss of additional instructional time for students.

Future research. One of the benefits of discontinuing the LTT is that resources designated for the LTT could be better utilized in pursuing new ways to improve the current main NAEP and information generated from it. The author, however, does not support the pursuit of the research idea proposed by Haertel that could potentially be "used to project current trend lines [for main NAEP and LTT] backwards in time." (p. 33) Haertel even ends his paper with the statement, "The resulting data sets would be for research only, and would have to be treated with *considerable caution*." (p. 34, emphasis added) The author is not convinced that the backwards projections will be of any useful benefit to policymakers.

High on the author's list of research priorities that the Governing Board should consider are to determine how to improve the participation rates of private school students on the NAEP assessments. The legislation that authorizes NAEP includes language "to report on the

academic performance of students… in public *and private* (emphasis added) elementary schools and secondary schools."

"In 2015, the school participation rates for private schools at both grades 4 and 8 did not meet the criteria so their results are not reportable." (https://www.nationsreportcard.gov/reading_math_2015/#reading/about%23footer?grade=4)

With the growing interest in discussions occurring nationwide on the issue of choice and programs like school vouchers for parents to use at schools of their choice (including private schools), it would be informative to have a more complete picture of student achievement nationwide to include data from private schools (beyond the results that sometimes occur for Catholic Schools). It appears that this has been an issue for a number of years. The author is aware of the NCES cautions of making comparisons between public and non-public schools (including private schools) and appreciates the information noted at https://nces.ed.gov/nationsreportcard/reading/interpret_results.aspx that "Users are cautioned against interpreting NAEP results as implying causal relations. Inferences related to student group performance or to the effectiveness of public and nonpublic schools, for example, should take into consideration the many socioeconomic and educational factors that may also have an impact on performance."

Conclusion and final caution. While the author is still convinced that the LTT should be discontinued and that attempts to merge the LTT with the main NAEP should not be pursued, there is one caution that needs to be mentioned if the Governing Board and the Commissioner of Education Statistics decide to seek a legislative solution to eliminate the LTT. Sometimes you get more changes than you asked for when you attempt to remove one requirement from a law. Let us hope that is not the case in convincing the U.S. Congress to remove the requirement for the LTT.

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Content of the Long-Term Trend Assessments Compared to Main NAEP

A reaction paper prepared for the National Assessment Governing Board

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February 2017

In December 2016, Edward Haertel from Stanford University prepared a white paper for the National Assessment Governing Board (Governing Board) on the future of the National Assessment of Educational Progress (NAEP) Long-Term Trend (LTT) assessments. The purpose of the white paper was to inform the Governing Board's deliberations as to whether LTT assessments should be continued independently from main NAEP assessments, whether it is feasible to blend LTT assessments with main NAEP assessment, and related questions. This paper delves more deeply into the issue of the considerable differences in content between the LTT assessments developed in the 1970s and 1980s and today's "gold standard" main NAEP. [2]

Reasons for Starting the LTTs

Beginning in the mid-1980s, NAEP made a large shift into what at the time was considered the modern era. As explained by Haertel, in 1984 NAEP moved from the Education Commission of the States to Educational Testing Service (ETS) under a new design and reporting approach based on item response theory (IRT) scales. Although not mentioned by Haertel, work began in 1988 on substantially updating the reading and mathematics frameworks for the Trial State Assessments (TSAs) to be inaugurated in 1990 and 1992. Considering changes in the design, reporting, and especially in the frameworks, it became clear that the existing item pools with vestiges dating back to the 1970s could not support the demands of the new frameworks and reporting goals. So, NAEP began two different data collections: 1) a scaled-back version of NAEP as it was in the 1980s to maintain comparability to the past ("Long-Term Trend" [LTT]), and 2) a modern NAEP based on new frameworks and innovative items as well as a new design and new procedures for data collection, analysis, and reporting ("main NAEP").

The TSAs had a profound impact on the content of NAEP. Anticipating the 1988 legislation authorizing the state-by-state assessments, in mid-1987 the federal government arranged for a special grant from the National Science Foundation and the Department of Education to the Council of Chief State School Officers (CCSSO). The grant was for the CCSSO to conduct a National Assessment Planning Project that had the primary responsibility for recommending objectives for the state-level mathematics assessment in 1990 (CCSSO, 1988).

The CCSSO's National Assessment Planning Project had a steering committee that included policymakers, practitioners, and citizens nominated by 18 national organizations, and a mathematics objectives committee comprised of mathematics educators from various states, mathematicians, parents, and citizens. According to the *1990 Mathematics Objectives*, the mathematics objectives committee did consider maintaining some of the content of prior assessments to allow reporting trends

[1] The author was involved in aspects of NAEP assessment development at Education Commission of the States from 1974 to 1983, and at Educational Testing Service from 1984 to 1994.

[2] The author expresses grateful thanks to the reviewers that contributed to improving this paper.

in performance. However, the committee also changed the framework in important ways. They decided that mathematics is far more holistic than implied by the content-by-process matrix used for the previous assessments, and organized the 1990 framework according to mathematical abilities and content areas with fewer, broader areas. They wanted to develop a forward-thinking assessment that could lead instruction, so they placed more emphasis on problem-solving, as well as geometry and algebra, and less on numbers. They also introduced a new calculator use policy for all three grades, and constructed-response questions designed to provide an extended view of students' mathematical abilities.

During this same period, Congress created the National Assessment Governing Board, giving it responsibility for formulating policy for NAEP including developing assessment objectives. Thus, in late 1989 and early 1990 the National Assessment Governing Board carried out the process of developing the updated reading framework for the continuation of the Trial State Assessments in 1992. To help with the *1992 Reading Framework*, the Governing Board awarded a contract to the CCSSO. The consensus development process involved a steering committee of members from 16 national organizations and a 15-member planning committee consisting of experts in reading. According to the *1992 Reading Framework*, the development guidelines included accounting for contemporary research on reading and expanding the range of assessment tools to new approaches and formats. Decisions about the framework incorporated substantial current research about the characteristics of good readers, and that reading is a dynamic, complex interaction among the reader, the text, and the context of any reading situation. The framework reflected these considerations by assessing reading for literary experience, reading to be informed, and reading to perform a task. The framework adopted the view of reading as an interactive, integrated process of constructing, extending, and examining meaning. Also, the Governing Board supported including many constructed-response items and selecting authentic texts drawn from materials used by students in real, everyday reading.

In contrast to the auspicious start of main NAEP in 1990 and its high quality since then, the LTTs began as subsets of previous NAEP assessments of reading and mathematics reported in the 1980s. The idea was to maintain a link to the past while moving into the future with main NAEP.

The LTTs were not planned to be carried forward indefinitely and have a varied history which often is overlooked:

- **1970s to 1980s—changing item pools**. From the first mathematics and reading assessments in the 1970s and early 1980s at the Education Commission of the States (ECS) through the 1980s at ETS, NAEP used a system of updating objectives with each cycle together with a policy of releasing items to the public and developing new items to respond to the updated objectives. Thus, by 1990 the item pools had changed to some extent over time but still had some "old" items. Haertel observed as part of his paper that it was surprisingly difficult to answer the question of what the LTT assessments in reading and mathematics actually assess.
- **1990s to present—fewer changes in the items pools**. During the 1990s, the subsets of LTT items were not changed. However, as noted by Haertel the LTT trend lines were disrupted in 2004 when various changes were made, including new testing accommodation policies that brought the LTT into conformity with the requirements of the individuals with Disabilities Education Act of 1990 and other legislation. (p.2) Updating the LTTs continued in 2008 although the 2004 scales were maintained.

Because of their history, the LTTs have no explicit frameworks, so as observed by Haertel, it is surprisingly difficult to answer the question of what the LTT assessments in reading and mathematics actually assess. As explained by Haertel:

> Rather, the LTTs began as collections of exercises,[3] operationalizing lists of objectives that changed over time. Some fraction of those items survived being released (i.e., were kept secure for reuse) and also survived screening on technical criteria, screening for bias, screening for outdated or obsolete content, or elimination on any other grounds. These surviving exercises, sometimes revised, augmented with some additional exercises intended to measure the same content, became the LTT exercise pools. (p.20)

It is important to recognize that the LTTs have **not** kept continually administering the exact same items over and over again since 1971 as believed by some people (see Haertel p.19). The LTT blocks began life in 1990 as subsets of NAEP assessments given in the 1980s that had been developed in accordance with objectives that had changed over time since the 1970s. The initial 1990 LTTs were readministered several times and then updated in 2004 and 2008. The most recent administration of the LTTs was in 2011-12.

Why the LTTs Are of Questionable Validity in Today's World

The LTTs are subsets of the NAEP reading and mathematics assessments that were widely viewed by educators in the late 1980s as assessing outdated views of reading and mathematics, so much so, that considerable energy was devoted to updating the content of the NAEP assessments for the Trial State Assessments. With advances in research during the past 20 years, the original LTT views have become further antiquated and can be expected to become increasingly so into the future:

- In reading, to be considered appropriate for the TSAs in 1992, the NAEP reading framework was updated to include an integrated view of reading comprehension. The International Reading Association had passed a resolution on assessment at its 1988 annual conference, stating, in part: "RESOLVED that…reading assessments reflect recent advances in the understanding of the reading process… [and that] assessment measures defining reading as sequence of discrete skills be discouraged."
- In mathematics, drawing on a report of "Issues in the Field" and *NCTM's Curriculum and Evaluation Standards* (1987), the NAEP mathematics framework was updated to be more holistic, to emphasize problem-solving (30 percent at all three grades), and to include more geometry and algebra, as well as calculators.

The LTTs are subsets of assessments developed according to different measurement and reporting approaches than are typical today. Arguably, the LTT items and assessments do not conform to current best practices:

- Because each item measured a relatively specific objective, there was a view that each item told its own story. Considerable energy was spent in providing reports of individual items together with the percentages of correct answers. Today, we are more confident about results based on *reliable* measures of constructs involving robust sets of items.

[3] In the 1970s, NAEP items were referred to as "exercises."

- To compare across ages, exactly the same items had to be used at ages 9 and 13, ages 13 and 17, and ages 9, 13, and 17. This meant 9-year-olds needed to be able to answer two portions of the items administered at age 13 (those at ages 9 and 13, and at 9, 13, and 17), and similarly 13-year-olds had to be able to answer two portions of the items given at age 17. This put a ceiling effect on the difficulty of the items that is particularly noticeable at age 17. In 1984, NAEP began using item response theory (IRT) scaling to enhance the comparability of results across ages, groups, and time, because estimated achievement based on IRT scaling is not dependent on specific items.
- The reading LTTs are comprised almost wholly of multiple-choice items, and the mathematics LTTs are 75 to 80 percent multiple-choice. Today's main NAEP assessments are at least half constructed response, if not more.
- The reading LTTs include passages developed specifically for NAEP, a practice that is not considered appropriate for main NAEP. Main NAEP uses authentic texts actually found and used by students in real, everyday reading.

There is considerable confusion about what the LTTs actually assess. Despite various claims on National Center for Education Statistics (NCES) websites, in blogs, or in publications, the LTT reading and mathematics assessments were not developed according to explicit content frameworks, or designed to measure particular sets of knowledge and skills:

- As noted in Haertel's paper (p.20), it is a widely held belief that the LTTs have tested the same items for more than three decades and so have a unique ability to track changes. However, the reality is that the LTTs have changed. The NAEP assessments underpinning the LTTs changed considerably in the 1970s and 80s, and, subsequently, the LTTs have kept changing even though much more slowly.
- All available descriptions of LTT frameworks are post hoc and therefore, subject to interpretation (including those reproduced in this paper). However, not all accounts of the LTT assessments are careful about describing them. For example, the NCES website used in part of Haertel's paper (p.22) (https://nces.ed.gov/nationsreportcard/**ltt**/**more**about.aspx) says that the LTT "uses substantially the same assessments decade after decade," and lists what the mathematics and reading LTTs were designed to measure.

Summary of Findings About LTT Content

This section summarizes the results of research into the content of the LTT assessments. The last two sections provide details about the aspects of content addressed in the research, first for reading and then for mathematics. In most cases, the content of the LTTs is compared to main NAEP to highlight the extent of the differences.

READING

The following summarizes the comparisons between the main NAEP and LTT reading assessments:

- Main NAEP reading assessments are based on a well-defined comprehensive framework that was developed using a legislatively defined process. According to the *2015 Abridged Reading Framework*, NAEP's definition of reading is grounded in scientific research. The **LTT** assessments are not based on frameworks. They are based on recreating blocks to replicate the same text

types with the same item formats at approximately the same level of difficulty as the released parent blocks developed in the 1970s and 80s.

- As described in the framework, main NAEP selects high-quality literary and informational material from authentic sources. **LTT** contains various disparate materials written for the assessment, primarily short expository pieces and documents. There is a category called "other" for riddles, visuals, and sentence matches.
- The average word length of main NAEP reading passages is 840 at grade 4, 924 at grade 8, and 1,174 at grade 12. These averages exceed the maximum length of the "long" passages in **LTT**, and most of the **LTT** passages are less than 150 words.
- At grade 4, students in main NAEP spend about half the assessment time responding to multiple-choice questions and the other half responding to constructed-response questions. Students in grades 8 and 12 spend a greater amount of time on constructed-response questions. In contrast, the **LTT** reading assessments are nearly all multiple-choice (92 to 95 percent).
- From 70 to 80 percent of the items in main NAEP are developed to measure higher-order reading cognitive behaviors (interpret and integrate, evaluate and critique). In comparison, the majority of the items in **LTT** assess retrieving basic information.
- Main NAEP includes a systematic assessment of vocabulary knowledge, and **LTT** does not.

By today's rigorous standards set by main NAEP as well as by the Progress in International Reading Literacy Study (PIRLS) and the Programme for International Student Assessment (PISA) international assessments, the passages and items in the LTT reading assessments are unlikely to be considered valid and robust assessments of reading. The LTTs assess straightforward comprehension of short pieces of text that are not authentic in the world of 2017, but are carefully replicated to retain their dated features. Reading comprehension is assessed almost wholly by multiple-choice questions. The LTT assessments will become increasingly irrelevant as students perform greater amounts of their reading online, and reading assessments move into the digital age.

MATHEMATICS

The following summarizes the comparisons for mathematics:

- Main NAEP's content areas describe an integrated view of mathematics that begins with a solid grasp of whole numbers and builds through measurement, geometry, statistics, and algebra to a firm foundation for learning calculus. In contrast, **LTT** has more content areas but there is little evidence of progression or integration in the objectives. At ages 9 and 13, more than half the items are devoted to numbers/numeration with about an equal smattering of variables/relationships, shape/size/position, measurement, and probability/statistics. The age 17 items are repeats of age 13. There is little content appropriate for age 17.
- Main NAEP ensures that students have a range of items across three levels of mathematical complexity—low, medium, and high. The **LTT** has an emphasis on "bare" computation.
- Any items resembling the high-complexity items in main NAEP seem to be missing entirely from the **LTT** examples that were available.
- In main NAEP, half the assessment time is devoted to constructed-response questions, including those requiring extended responses where students can demonstrate their thinking and problem-solving skills. The majority of the **LLT** items are multiple-choice and the rest are short answer (e.g., one or two digit numerical answers).

- Main NAEP has a rigorous review process to ensure the item content is appropriate to today's environment. In contrast, the **LTT** items appear to have much more emphasis on the metric system and vocabulary generally than the curriculum has today, especially at age 9.

The mathematics assessments on which LTT is based focused on assessing growth in the **same** mathematics from age 9 to 13, age 13 to 17, and age 9 to 13 to 17, leaving little relevant only to age 17. The LTTs emphasize knowledge and skill much more than problem-solving, making them essentially basic skills assessments, with some of the content outdated.

Comparing the Content of Main NAEP Reading Assessments (2009-2015) with the LTT Reading Assessments (1990-2012)

The detailed look at the content of the reading LTTs is focused on the LTTs since the 1990s, because as explained in the introduction to this paper, that is about when the reading LTTs came into existence. Since then, the LTTs have been modified somewhat to provide accommodations to students with disabilities and English language learners, but the knowledge and skills remain essentially the same.

Gloria Dion, director of NAEP Test Development at Educational Testing Service (ETS) explained: "While there is a document of broad objectives from 1983-84, there is no framework or specifications document for the LTT Reading Assessment" (personal communication, December 2016).[4] Since the first LTT assessments, there have been some reconfigurations and some blocks released in 2004 and 2008. However, Dion continued, "the development process for new blocks has been a close replication of the types of texts and items in the original parent instrument. That is, the new LTT reading blocks are developed to assess the same text types with same item format at approximately the same level of difficulty as the released parent block at each age." (personal communication, December 2016)

To highlight the differences between the content of today's state-of-art NAEP reading assessments and the field prior to 1990, characteristics of today's main NAEP are provided followed by information about the reading LTTs.

Definition of Reading

Main NAEP. According to the *2015 Abridged Reading Framework* published by the National Assessment Governing Board (National Assessment Governing Board, 2015a), the reading framework presents the assessment's conceptual base and discusses its content. The framework has not been changed since 2009 and applies to the assessments between 2009 and 2015 (the previous framework was used from 1992 through 2007).

The main NAEP reading assessments are guided by a definition of reading that reflects scientific research, draws on multiple sources, and conceptualizes reading as an active and complex process that involves:

- Understanding written text
- Developing and interpreting meaning
- Using meaning as appropriate to the type of text, purpose, and situation

[4] The author is very grateful to Gloria Dion, Patricia Donahue, and Shannon Richards of ETS for providing invaluable information about the LTTs and main NAEP.

LTT. As explained above, while there are NAEP objectives from 1983-84 (an assessment containing items in the LTTs) there is no framework or specifications document for the LTT reading assessment. The LTT most likely also contains items from previous NAEP assessments. Backtracking—the *1983-84 Reading Objectives* (NAEP, 1984) were based on the 1979-80 objectives combining reading and literature, which were preceded by two sets of reading objectives in 1970 and 1975 as well as two sets of literature objectives in 1970 and 1975. Perhaps because of integrating reading and literature, the 1983-84 objectives had a more fragmented view of reading than today's NAEP, including two separate objectives that dealt with comprehension—comprehension (basic understanding, primarily of expository passages) and extends comprehension (deliberate, conscious analyses, primarily of literary passages).

Types of Texts

Main NAEP. According to the *2015 Abridged Reading Framework*, reading passages are selected to represent high-quality literary and informational material, such that many NAEP passages require interpretive and critical reading skills. The assessments include two types of texts:

- Literary texts—fiction, literary non-fiction (e.g., essays, speeches, biographies), and poetry. Several aspects of text structures and features, as well as literary techniques, may be assessed for all grades. At grade 4, this includes problem conflict, figurative language, cause and effect, point of view, diction and word choice, and organizational patterns in poetry such as verse and stanza, along with the basic elements of rhyme scheme, rhythm, mood, themes, and intent. These components become increasingly sophisticated as students move through elementary, middle, and high school grades. For example, grade 12 includes dramatic irony, denotation and connotation, rhetorical devices, high levels of abstraction, and complex poetry arrangements.
- Informational texts—exposition, argumentation and persuasive texts, and procedural text and documents. At grade 4, this includes textbook passages, news articles, encyclopedia entries, sequences, point of view, evidence, compare and contrast, and procedural text supplementary to continuous text. These are represented in grade 8 and 12 with increasing complexity. Some examples at grade 12 include social commentary essays, historical accounts, persuasive brochures and advertisements, manuals, and contracts.

Examples of texts included in the *2015 Abridged Reading Framework* were: grade 4—*Little Great White* by Pamela S. Turner, an expository text about how scientists care for a white shark in captivity; grade 8—*FUN* by Suzanne Britt Jordan, a literary nonfiction text about the concept of fun; and grade 12—Theodore Roosevelt's 1905 inaugural address about the duties and responsibilities of being president.

Further information about the number of main NAEP texts and their lengths was obtained from the work of two expert panels convened by the National Center for Education Statistics (NCES): *A Comparison of the PIRLS 2011 and NAEP 2011 Fourth Grade Reading Assessments* and *Comparison of the PISA 2009 and NAEP 2009 Reading Assessments.*

Table 1 shows that the main NAEP assessments have 12 passages at grade 4; and 16 and 17 passages at grades 8 and 12. At grades 4 and 8, the passages are evenly divided between literary and informative, but grade 12 includes more informative passages. Passages (or pairs of passages) are presented in 25-minute blocks, followed by about 9-11 items at grades 8 and 12.

Table 1. NAEP Passage Text Types

	Literary	Informative
Grade 4 (2011)	7	5
Grade 8 (2009)	8	8
Grade 12 (2009)	4	13

Notes: At grade 4, the literary passages included four fiction, one non-fiction, and two poems (NCES: NAEP and PIRLS comparison). At grade 8, passages were evenly distributed, including two poems; at grade 12, about one-quarter were literary (including one poem) and about three-quarters were informational "to mirror the distribution of the kinds of texts students encounter as they progress through the education system" (NCES: NAEP and PISA comparison).

LTT. The 1983-84 NAEP objectives do not describe the types of texts to use in the assessments, but they do call for comprehending various types of written materials and reading for a variety of purposes. The examples of texts included shopping lists, complex essays, literary works, science textbooks, historical essays, mail-order catalogs, instructions to assemble a bicycle, research reports, a play, dictionaries, encyclopedias, bibliographies, and abstracts.

NAEP has classified the texts in the LTT reading assessments in three categories: expository, narrative, and document/other (for riddles, visuals, and sentence matches). There are 10 15-minute blocks at each age—9, 13, and 17. The number of texts per block ranges from three to six. A substantial portion of the blocks are common across ages: 9 and 13, 13 and 17, and ages 9, 13, and 17. The total number of items in 2012 was 88 at age 9, 106 at age 13, and 103 at age 17.

Table 2 shows the distribution of items according to text type (P. Donahue, personal communication, January 2017). Combining the expository and document/other categories, the LTTs basically assess informational reading at all three ages. This is different than the relatively equal distribution of literary and information texts in main NAEP at grades 4 and 8, although there is a better match at grade 12.

Table 2. Distribution of LTT Reading Items by Text Type

	Age 9		Age 13		Age 17	
Text Type	Number	Percentage	Number	Percentage	Number	Percentage
Expository	58	66%	63	59%	73	70%
Narrative	21	24%	19	18%	13	13%
Document/Other	9	10%	24	23%	17	17%

The LTT passages from the 1990 LTTs on the NAEP Questions Tool website, half released in 2004 and half in 2008, are still representative of the LTT reading assessments as updated after 2004 and 2008 (P. Donahue, personal communication, January 2017). The website shows about five passages per age, about half of which overlap grades. Taken together, the passages represent a variety of written materials and purposes. Some topics appear dated (e.g., paper routes, tall tales) or are unsuitable for a broad range of students (e.g., poem asking mother for dog). There are a disproportionate number of passages about history (e.g., frontier women, elephant seal hunting, starting work as a teenager in the 1900s, women getting to vote), probably because historical topics have less likelihood of becoming further dated.

Length of Reading Passages

Main NAEP. Table 3 shows the length of the main NAEP reading passages. The expert panels comparing NAEP to PIRLS and PISA, respectively, both mentioned that NAEP had the longest passages.

Table 3. NAEP Reading Passage Word Counts

	Grade 4 (2011)	Grade 8 (2009)	Grade 12 (2009)
Average number of words	840 (721 with poetry)	923.6	1173.5
Range of words in passages	47-1,147	219-1,429	771-1,429

Notes: At grade 4, the NAEP passages (including pairs of passages) were longer than the PIRLS passages with the exception of NAEP's two poems (47 words and 197 words).

LTT. Table 4 shows general specifications for the LTT reading assessments, which indicates the lengths of LTT reading passages (P. Donahue, personal communication, January 2017). At all three grades, the LTT passages are substantially shorter than those in main NAEP. Also, with shorter passages and shorter blocks, there are fewer items per passage.

Table 4. General Specifications for Lengths and Number of LTT Reading Items per Passage (based on LTT passages in the past)

	Long Passages		Short Paragraphs and Poems	
	Number of Words	Number of Items	Number of Words	Number of Items
Age 9	250-500	3-6 MC or 2MC w/ 1 long answer	50-125	1-2 MC
Age 13	250-625	3-6 MC or 2-3MC w/ 1 long answer	50-125	1-2 MC
Age 17	250-800	same	50-150	1-2 MC

Notes: "Other" tasks include several illustrations at each age. For example, cereal boxes, directions, and snowman at age 9, each with one multiple-choice question; telephone bill, traffic ticket, coupon, advertisement, and table at ages 13 and 17, each with two to three multiple-choice questions at age 13 and three multiple-choice questions at age 17.

Passage Difficulty

Main NAEP. Table 5 provides information about the difficulty of the passages in main NAEP. Several readability formulas were used to compare passage difficulty between NAEP and PIRLS at the 4th grade (the three shown in the table and the Fry Graph with 6.9 average grade level) and NAEP and PISA at the 8th and 12th grades (the three shown in the table and the FORCAST Formula for non-continuous text). The measures in table 5 were selected to summarize comparisons across grades on measures of continuous text (rather than forms and graphics such as used in PISA).

It should be noted that the expert panel comparing NAEP and PIRLS cautioned that readability formulas are used as a quick assessment of the difficulty of text and do not account for certain features of the text that also have influences on reading comprehension, such as text structure, topic, and appeal.

Table 5. Average Readability Levels of NAEP Reading Passages

Readability Measure	Grade 4 (2011)	Grade 8 (2009)	Grade 12 (2009)
Flesch Reading Ease Score	Fairly easy (score 76.5)	Standard (score 69.4)	Standard (score 62.4)
Flesch-Kincaid Grade Level	5.9	7.5	8.8
Lexile	Sixth grade (score 910)		
Dale-Chall Grade Level Formula		6.9 Average (range 5.2 - 8.3)	7.4 Average (range 5.4 - 9.4)

Notes from NCES expert panel reviews:
The Flesch Reading Ease measure is based on the number of words, syllables, and sentences in adult reading materials.
The Flesch-Kincaid Grade Level is most reliable when used to assess upper elementary and secondary materials. It is based on the number of words, syllables, and sentences in a text, but with different weighting than the Flesch Reading Ease measure.
The Lexile analysis takes into account sentence length and word frequency.
The Dale-Chall Formula uses a familiar words list common to students and rates the text against it as well as the text's total number of words and sentences.

LTT. There did not seem to be any information available on the difficulty levels of the written materials in the LTT reading assessments. However, given the overlaps across ages and the short passages, it seems likely that the LTT texts would have lower reading difficulty than main NAEP, which already may be low at grade 8 and especially at grade 12.

Item Response Mode

Main NAEP. At grade 4, students spend about half of the assessment time responding to multiple-choice questions and the other half responding to constructed-response questions. Students in grades 8 and 12 spend a greater amount of time on constructed-response questions.

LTT. Table 6 shows that the LTT reading assessments are comprised almost wholly of multiple-choice items.

Table 6. Percentages of Multiple-Choice and Constructed-Response Items in the NAEP LTT Reading Assessments

Item Format	Age 9	Age 13	Age 17
Multiple-Choice	95%	93%	92%
Constructed Response	5%	7%	8%

Cognitive Targets

Main NAEP. NAEP addresses three sets of cognitive reading behaviors, with 30 percent of the items at grade 4 asking students to locate and recall information, but only 20 percent at grades 8 and 12. At all three grades, about half the NAEP reading assessment items require students to integrate and interpret the information they have read—50 percent at grades 4 and 8, and 45 percent at grade 12. As much as another one-third of the assessment asks students to evaluate the quality of the texts—20 percent at grade 4, 30 percent at grade 8, and 35 percent of grade 12. This means from 70 to 80 percent of the items should assess higher-level cognitive targets. Considering both the passages and the items, the NCES expert panel comparing NAEP and PIRLS concluded that "the NAEP 2011 reading assessment may be more cognitively challenging than PIRLS 2011 for U.S. fourth-grade students" (NCES, 2011, p.17).

- Locate and recall—identify main ideas and supporting details, essential elements of a story.
- Integrate and interpret—compare and contrast, examine relationships across different parts of texts or multiple texts, process information logically and completely, relate texts to their own experiences.
- Critique and evaluate—view text objectively, assess text critically from numerous perspectives and synthesize it with other texts and experiences, judge the effectiveness of specific textual features.

LTT. According to the NAEP Questions Tool, the LTT items have the following content classifications:

- Comprehends What Is Read
- Analyzes What Has Been Read
- Interprets What Has Been Read
- Evaluates What Has Been Read (only at ages 13 and 17)

These classifications may have been derived from the *1983-84 Reading Objectives*. In that document, "Comprehends What Is Read" is the first major objective and "Extends Comprehension" is the second major objective, but the second objective has three sub-objectives: "Analyzes," "Interprets," and "Evaluates What Has Been Read."

Haertel's paper contained a different classification of the LTT reading items. Although accompanied by a footnote that NCES descriptions of LTT were sometimes inconsistent, Haertel reported the following about the LTTs from the NCES website previously cited in this paper:

"The NAEP long-term trend reading assessment… was designed to measure students' ability to

- Locate specific information in text provided,
- Make inferences across a passage to provide an explanation, and
- Identify the main idea in the text."

Reinforcing the point about inconsistency of information about LTT, ETS has different classifications for the LTT reading items: identify main idea, locate information verbatim, locate information, and inference (G. Dion, personal communication, December 2016).

Despite the alternative sources about classifications, the documentation in the NAEP Questions Tool and looking at the released items suggests that the LTT items primarily assess information retrieval. However, there are only 19 released items at age 9, 19 released items at age 13, and 16 released items at age 17, with many overlap items.

Vocabulary Assessment

Main NAEP. *The 2009 Reading Framework* introduced a new systematic assessment of vocabulary knowledge. The vocabulary assessment involves the interpretation of words in the context of a passage. The vocabulary items function both as a measure of passage comprehension and as a test of specific knowledge of a word's meaning. A sufficient number of vocabulary questions at each grade provide reliable and valid information about students' vocabulary knowledge.

LTT. The LTTs may have some isolated items asking about vocabulary. However, systematic assessment of vocabulary knowledge is not part of the LTTs.

Comparing the Content of Main NAEP Mathematics Assessments (2009-2015) with the LTT Mathematics Assessments (1990-2012)

The detailed look at the content of the mathematics LTTs is focused on the LTTs since the 1990s, because as explained in the introduction to this paper, that is about when the mathematics LTTs came into existence. Since then, the 2004 and 2008 LTTs were modified somewhat to provide accommodations to students with disabilities and English language learners but the knowledge and skills remain essentially the same (Institute of Education Sciences, National Center for Education Statistics, 2009).

Mathematics Content Domains

Main NAEP. According the *2015 Abridged Mathematics Framework* published by the National Assessment Governing Board (National Assessment Governing Board, 2015b), the framework applies to the 2009-2015 assessments. In 2009, modifications were made to introduce clarifications at grades 4 and 8, and new content objectives were introduced at grade 12 to identify the essential mathematics knowledge and skills required for college and workplace training.

The 2015 Mathematics Framework specifies that NAEP assessment questions measure one of five mathematical content areas:

- Number properties and operations—including computation and understanding of number concepts
- Measurement—including use of instruments, application of processes, and concepts of area and volume
- Geometry—including spatial reasoning and applying geometric properties
- Data analysis, statistics, and probability—including graphical displays and statistics
- Algebra—including representations and relationships

The following summarizes the grade expectations for each of the content areas, beginning with **number properties and operations**. At grade 4, students should have a solid grasp of whole numbers and begin to understand fractions. They should be able to identify place values, and add, subtract, multiply, and divide whole numbers. At grade 8, they should be comfortable with decimals, percentages, and common fractions, and be able to solve problems involving proportionality and rates. They should have some familiarity with naturally occurring irrational numbers (e.g., square roots, pi). By grade 12, students should be able to establish the validity of numerical properties using mathematical arguments.

Measurement focuses on length (perimeter, distance, and height) at grade 4; areas and angles at grade 8, and volumes and rates (e.g., speed) at grade 12. **Geometry** has developed into the study of the possible structures of space. At grade 4, this includes figures in the plane (lines, circles, triangles, rectangles, and squares) and in space (cubes, sphere, and cylinders). At grade 8, there is an emphasis on understanding properties of figures, such as parallelism, perpendicularity, and angle relations, and a mixing with measurement. By grade 12, geometry and algebra merge to provide the basis for calculus. In **data analysis, statistics, and probability,** students at grade 4 should be able to compare two data sets and understand the basic concepts of chance. By grade 8, they should be able to use data organizing and summarizing techniques, analyze statistical claims, and make statistical inferences; such that by grade 12, they should be able to use a wide variety of statistical techniques, including fitting models to data.

Algebra at grade 4 emphasizes extending numerical patterns and the idea of unknown quantities. By grade 8 students should be familiar with linear functions, and by grade 12 students should be familiar with nonlinear functions as well as with expressions involving several variables, systems of linear equations, and solutions to inequalities.

Table 7 shows the operational distribution of items across the content areas in the 2013 Mathematics Assessment (S. Richards, personal communication, January 2017). At grade 4, the assessment emphasizes number properties and operations (40 percent), but that is not the case at grades 8 and 12. Grade 8 emphasizes algebra (30 percent) the most, with 15 to 19 percent in each of the other areas. At grade 12, more than half the assessment is in two areas—algebra (32 percent) and data analysis, statistics, and probability (24 percent).

Table 7. 2013 NAEP Mathematics Distribution of Items by Content Area

Content Area	Grade 4	Grade 8	Grade 12
Number Properties and Operations	40% (60)	19% (29)	12% (22)
Measurement	18% (27)	19% (29)	12% (22)
Geometry	15% (22)	17% (26)	19% (37)
Data Analysis, Statistics, and Probability	13% (19)	15% (23)	24% (46)
Algebra	15% (22)	30% (46)	32% (62)
Total	150	153	191

LTT. The beginning chapters of the *1981-82 Mathematics Objectives* published by the Education Commission of the States (National Assessment of Educational Progress, 1981) provide a brief history of the first three mathematics assessments. As described by Haertel, a three-dimensional classification scheme was used to categorize the mathematics objectives for the first assessment during the 1972-73 school year: uses of mathematics, content (17 areas), and objectives and abilities. Haertel observes that "almost half a century later, some of these early objectives seem quite dated, and others seem out of place in a mathematics assessment." This is not surprising, since in developing the 1972-73 objectives, they were compared with other statements in mathematics education literature and found to be consistent with objectives appearing in the preceding 25 years (back to 1947). About half the items from the first assessment were released, but the other half were retained for measuring trends in the second assessment during 1977-78 and beyond.

The objectives for the second mathematics assessment were changed considerably and organized into a content-by-process matrix. This content-by-process matrix also was used for the third assessment in 1981-82, and also updated for the fourth assessment in 1985-86*. So, it makes some sense that NAEP uses the content domains from the* 1981-82 Mathematics Objectives to describe the LTT trend assessment.

The content domains from the 1981-82 objectives included:

- Numbers and numeration
- Variables and relationships
- Shape, size and position

- Measurement
- Probability and statistics
- Technology (not in LTT)

Courtesy of ETS, table 8 contains the distribution of the current mathematics LTT according to the content described in the *1981-82 Mathematics Objectives* (S. Richards, personal communication, January 2017). The items are contained in six 15-minute blocks, with half of them overlapping ages—one each for 9 and 13, 13 and 17, and 9, 13, and 17. There are 137 items at age 9, 157 at age 13, and 157 at age 17. Considering that the total assessment time is 90 minutes, this does not provide very much time for each item (about 30 seconds). These time limitations suggest short, factual questions. The majority of the items at ages 9 and 13 assess numbers and numeration, as do 42 percent at age 17. At age 17, more emphasis on numbers (42 percent) than algebra (27 percent) is very different from main NAEP. Also, there is little attention to probability and statistics and no attention the more up-to-date content related to data analyses.

Table 8. 2012 LTT Mathematics Operational Blocks by Content Area

Content Area	**Age 9**	**Age 13**	**Age 17**
Numbers and Numeration	53% (72)	52% (82)	42% (67)
Variables and Relationships	11% (15)	11% (18)	27% (43)
Shape, Size, and Position	9% (12)	11% (18)	11% (17)
Measurement	15% (20)	14% (22)	12% (19)
Probability and Statistics	13% (18)	11% (17)	7% (11)
Total	137	157	157

Information about the actual content of the LTT mathematics items was obtained from the NAEP Questions Tool, which contains 40 released items at age 9, 43 released items at age 13, and 53 released items at age 17 (https://nces.ed.gov/NationsReportCard/nqt/Search/SearchOptions). Additionally, ETS forwarded "*Appendix 1: Mathematics Content Objectives by Age Level*" which contained "item descriptions of the current long-term trend items" matched to the 1981-82 objectives. Unfortunately, appendix 1 is only a copy of appendix 1 from an unknown publication with an unknown date that has been passed forward in a file drawer. Nevertheless, this is additional "public" documentation and the author is grateful to have it. Appendix A to this document contains the information in the mysterious appendix, which lists descriptions for 54 items at age 9, 76 at age 13, and 51 at age 17.

Looking across the LTT trend items in the NAEP Questions Tool together with the item descriptions in appendix A reveals information about the content of LTTs (even though some questions overlap). At age 9, consistent with the distribution across the content areas, the majority of the items assess numbers and numeration, and the majority are multiple-choice. Nearly all the short constructed-response items require single- or double-digit numerical answers. There are items about place value and as many as 20 items requiring basic computation. There appears to be a disproportionate number of items requiring symbol and vocabulary recognition, especially concerning the metric system (e.g., >, X, =, prime number, kiloliter, pentagon, circumference, degree, fifths, kilogram, kilometer). There are several number sentences, and an item about the property of a square. There also are more than a dozen items involving reading tallies, tables, charts, and graphs, and one on the concept of probability. The items are not classified according to process domain categories. However, very few would be considered

moderate-complexity items and none high-complexity items, even though according to ETS 31 percent (42) are classified as application and problem-solving (see table 10).

At age 13, again, the majority of the items assess numbers and numeration, including decimals, fractions, and percentages. There are a few that would seem unusual in light of today's curriculum (e.g., two on improper fractions, and the meaning of 0.7 percent). There are about half a dozen examples in variables and relationships, including several algebraic expressions but also several logic statement items. Fewer than 10 examples are in geometry, and only a couple in probability and statistics. Again, most of the items are multiple-choice and they are not classified according to process. There is very little problem-solving.

At age 17, about half the items assess number and numeration, including decimals, fractions, and percentages similar to age 13. The next largest group of items assesses variables and relationships, consistent with the distribution across the content areas shown in table 8. However, almost all of the items are the same as those at age 13. One of the few "hard" questions, described as "reason about an algebraic equation" was: If P/41= 64, what does P/82 equal? Ans:32. The same as at ages 9 and 13, most are multiple-choice, and the process classifications are not provided. However, among the released questions and the item descriptions, there are hardly any items that could be considered for age 17 only. This is a serious concern, especially considering that the high-complexity types of items are nonexistent.

Process Domains

Main NAEP. The framework for main NAEP does not have cognitive processes. It uses a hierarchical model called levels of mathematical complexity, with low, moderate, and high as three levels.

- Low-complexity questions require students to recall or recognize concepts or procedures specified in the framework.
- Moderate-complexity questions involve more flexible thinking and choice among alternatives. The student needs to decide what to do and how to do it.
- High-complexity questions make heavy demands on students to use reasoning, planning analysis, judgement, and creative thought. Students may need to justify mathematical statements, construct a mathematical argument, or generalize from specific examples.

Table 9 shows the operational distribution of items by mathematical complexity for the 2013 mathematics assessment (S. Richards, personal communication, January 2017). The majority of mathematics items in main NAEP are considered to have low mathematical complexity. Most of the rest have moderate complexity, and about 5 percent high complexity.

Table 9. 2013 NAEP Mathematics Distribution of Items by Cognitive Complexity

Mathematical Complexity	Grade 4	Grade 8	Grade 12
Low	58% (87)	56% (86)	55% (106)
Moderate	36% (54)	39% (60)	39% (75)
High	6% (9)	5% (7)	5% (10)

LTT. The process domain for the objectives in the 1981-82 Mathematics Assessment had five categories, with each category suggesting a mental process.

- Mathematical knowledge—refers to the recall and recognition of mathematical ideas. It ordinarily relies on the memory process.
- Mathematical skill—refers to the routine manipulation of mathematical ideas and relies on algorithmic processes that are standard procedures leading to answers.
- Mathematical understanding—refers to the explanation and interpretation of mathematical knowledge and relies primarily on translation processes.
- Mathematical application and problem-solving—refer to the use of mathematical knowledge, skill and understanding in solving both routine and nonroutine problems. These items require a sequence of processes; reasoning and decision-making processes must be used.
- Attitudes toward mathematics (not in the LTTs)

Table 10 shows how the LTT items have been distributed across the process categories (G. Dion, personal communication, December 2016). However, care should be taken in interpreting the data in this table. As observed above, there are very few, if any, problem-solving items contained in the released items or in the item descriptions. It is possible that the bulk of items placed in the application and problem-solving category are application rather than problem-solving.

Table 10. 2012 LTT Mathematics Operational Blocks by Process Domain

Process Domain	Age 9	Age 13	Age 17
Mathematical Knowledge	23% (32)	15% (23)	15% (24)
Mathematical Skill	35% (48)	48% (76)	46% (73)
Mathematical Understanding	11% (15)	16% (25)	16% (25)
Mathematical Application and Problem-Solving	31% (42)	21% (33)	22% (35)
Total	137	157	Total

Question Formats

Main NAEP. Testing time on NAEP is divided evenly between multiple-choice questions and two types of constructed-response questions. Short constructed-response questions require students to give either a numerical result or the correct name or classification for a group of mathematical objects, draw an example of given concept, or possibly write a brief explanation for a given result. Responses can be scored correct/incorrect or partially correct. Extended constructed-response questions require students to consider a situation that demands more than a numerical or short response. For example, the student may be asked to describe a situation, analyze a graph or table of data, or set up and solve an equation given a real-world problem.

LTT. The LTTs use two types of questions—multiple-choice and short constructed response. Table 11 shows the operational distribution of item types in the 2012 LTT mathematics assessments (S. Richards, personal communication, January 2017). From 74 to 80 percent of the items are multiple-choice. In contrast to main NAEP, there are even more multiple-choice questions at age 17.

Table 11: 2012 LTT Mathematics Operational Blocks by Item Type

Item Type	Age 9	Age 13	Age 17
Multiple-Choice	74% (102)	76% (120)	80% (126)
Constructed Response	26% (35)	24% (37)	20% (31)
Total	137	157	157

Calculator Use

Main NAEP. About two-thirds of the assessment blocks at each grade contain questions for which calculators are not allowed. The other one-third of the blocks allow calculator use and contain some questions that would be difficult to solve without a calculator.

- Grade 4: A four-function calculator is supplied to students
- Grade 8: A scientific calculator is supplied to students
- Grade 12: Students are allowed to bring whatever calculator, graphing or other, they are accustomed to using in the classroom, with some restrictions for test security purposes. For students who do not bring a calculator to use on the assessment, NAEP will provide a scientific calculator. Having a graphing calculator is not an advantage in answering the NAEP questions.

LTT. The LTT mathematics assessments do not allow calculators, although some early NAEP mathematics assessments did consider calculator use. According to Mary Lindquist, the 1977-78 assessment even included a special booklet to conduct a calculator study. At that point in time, however, students had to be trained on how to use the calculator and they often took longer with the calculator (M. Lindquist, personal communication, January 2017).[5]

This accentuates the differences between then and now, with the move toward digital assessments of mathematics in NAEP and the states in the United States, and internationally in the Trends in International Mathematics and Science Study (TIMSS) and PISA.

Conclusion

Haertel summarizes a number of arguments against maintaining the LTTs in their current form, with the last reason being the most important (p.23):

- It is expensive.
- Maintaining two trends is confusing.
- That performance on outdated content is no longer of interest to policymakers or other stakeholders.
- A range of changes in schooling, in assessment technology, and in society at large are rendering the results irrelevant and possibly invalid.

Looking carefully at the content of the LTTs, including the released items in the NAEP Questions Tool, calls the quality and relevancy of the LTTs into question. In today's reach for higher education standards as presented by the National Assessment Governing Board, how students performed on yesterday's

[5] Mary Lindquist, past President of the National Council of the Teachers of Mathematics, was an ECS mathematics consultant for the 1977-78, 1981-82, and 1985-86 NAEP assessments, and participated in CCSSO's 1990 National Assessment Planning Project as a member of the mathematics objectives committee.

assessment may not be particularly relevant, especially compared to the results on state-of-the-art main NAEP.

Additionally, there are indications that people do not understand what the LTTs are, including the seriously erroneous view that the LTTs have been giving the same assessment items since 1971. As a more appropriate view, Haertel's paper includes two graphics from the Executive Summary of the 2012 NAEP Long-Term Trend report showing a break in the LTT trends in reading (NCES, 2013). There are solid lines back to 2004 when the new accommodation procedures were implemented, and then broken lines showing some issues with trend accuracy back to 1971.

Taking concerns about the LTTs' quality into consideration together with the various misunderstandings about what they actually are measuring and for how long raises concern about their validity. In times of scarce funding resources, the expense of fielding LTTs must be considered in view of other priorities. For example, the Governing Board has been conducting extensive research into whether NAEP can be a valid indicator of college and career readiness (National Assessment Governing Board, 2013 and 2016). If tradeoffs need to be made, it makes more sense to extend NAEP into areas more in tune with the future than the past, and move NAEP forward toward its goal of helping our 8th and 12th grade students be better academically prepared for education and job training after high school.

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Appendix A

Item Descriptions for LTT Long-Term Trend Mathematics

Numbers and Numeration

Number Concepts (whole numbers, fractions, decimals, percentages, and integers)

Age 9: Apply place value (2), Identify greatest money value (2), Identify greatest number (1), Relate part to whole (1), Understand place value (3)

Age 13: Change decimal to percent (1), Convert decimal to percent (1), Convert fraction to decimal (3), Identify greatest number (1), Identify number line property (1), Write improper fraction (1), Understand concept of percent (1), Understand decimal place value (1), Understand percent less than 1 (1)

Age 17: Convert decimal to fraction (3), Convert percent to decimal (1), Identify number line property (1), Understand concept of percent (1), Understand decimal place value (2), Understand opposite of an integer (2), Use concept of percent (1)

Operations (whole numbers, fractions, decimals, percentages, and integers)

Age 9: Add whole numbers (4), Divide whole numbers (2), Multiply whole numbers (2), Subtract whole numbers (3), Apply multiplication (1), Apply operation of addition (1), Apply operation of subtraction (1)

Age 13: Add whole numbers (3), Add integers (1), Divide integers (2), Subtract whole numbers (6), Find percent given numbers (2), Find percent greater than 100 (2), Find percent of number (1), Apply operation of addition (1)

Age 17: Add integers (2), Divide integers (2), Multiply fractions (3), Subtract decimals (1), Find number given percent (1), Find percent given numbers (1) Find percent greater than 100 (2), Find percent of number (2), Identify sign of divisor (1), Simplify square root (1)

Estimation

Age 9: Estimate large number (1)

Age 13: Estimate cost of pencils (1), Estimate cost using percent (1), Estimate total cost (1)

Age 17: Estimate cost of pencils (1), Estimate cost using percent (1), Estimate square root (2), Estimate total cost (1)

Properties

Age 9: Use property of transitivity (1)

Age 13: Apply transitive property (1), Identify even number property (2), Use property of transitivity (1)

Variables and Relationships

Relations

Age 13: Find common factor (1), Identify even number (1)

Use of Variables

Age 9: Translate words into numbers (1), Write multiplication sentence (1)

Age 13: Add monomials (1), Identify algebraic identify (1), Identify number sentence (1), Write addition sentence (1)

Age 17: Add monomials (1), Apply concept of inequality (1), Define equivalent equations (1), Identify algebraic identity (1), Identify linear inequality (1), Multiply equation by a constant (1)

Functions and Formulas

Age 13: Evaluate algebraic expression (1)

Age 17: Evaluate algebraic expression (1), Evaluate function for value (1)

Operations with Variables

Age 9: Solve number sentence (2)

Age 13: Solve number sentence (1)

Age 17: Solve number sentence (1)

Shape, Size, and Position

Recognition of Figures

Age 9: Apply property of square

Age 13: Identify a sphere (1), Identify parallelograms (1)

Age 17: Identify a sphere (1), Relate circle to square

Definitions, postulates, and theorems

Age 13: Identify parallel lines (1), Identify perpendicular lines (1), Apply supplementary angles (1), Apply vertical angles (1), Apply triangle inequality (1)

Age 17: Apply angle addition property (1), Identify parallel lines (1), Identify perpendicular lines (1), Apply supplementary angles (1), Apply vertical angles (1), Use properties of triangles (4)

Measurement

Units/Estimation of Measurements

Age 9: Estimate weight (metric) (1), Identify greatest metric unit (1)

Age 13: Convert metric unites (2), Estimate difference in length (1), Estimate height of door (1), Estimate total weight (1), Identify greatest metric unit (1), Identify unit of length (1), Identify unit of weight (1)

Age 17: Estimate circumference (1), Estimate difference in length (1), Estimate height of door (1), Estimate total weight (1), Estimate weight (1), Relate meter to yard (1)

Instrument Reading

Age 9: Read scale (1)

Age 13: Read length using ruler (1), Use ruler to measure length (1)

Area, Perimeter, and Volume

Age 9: Determine amount of change (1), Determine distance on a map (1), Find area of rectangle (2), Find perimeter of rectangle (2)

Age 13: Find area of rectangle (2), Find area of square (1), Find perimeter of rectangle (2)

Age 17: Find area given perimeter (1), Find area of irregular shape (1), Find area of rectangle (1)

Probability and Statistics

Organizing, displaying, and interpreting information (tallies, tables charts, and graphs)

Age 9: Interpret data in bar graph (1), Interpret data in circle graph (1), Interpret data in table (1), Interpret tally chart (1), Read circle graph (1), Read data from table (1), Read data in bar graph (1), Read tally chart (2), Compute using data in table (1), Compute with data in bar graph (1)

Age 13: Interpret data in bar graph (1), Interpret data in circle graph (1), Interpret data in table (1), Read circle graph (1), Read data from table (1), Read data in bar graph (1), Compute using data in table (1), Compute with data in bar graph (1)

Age 17: Interpret data in table (2), Interpret line graph (1), Read line graph (1), Compute using data in table (2)

Probability (simple, compound and independent events, odds)

Age 9: Apply concept of probability (1)

Age 13: Identify expected value (1), Understand probability (1),

Age 17: Identify expected value (1)

Note: At the time appendix 1 was developed, the LTTs also included some items from mathematical methods and discrete mathematics, areas introduced in 1985-86. More specifically, note that at the time appendix 1 was developed, the LTTs also included some items from mathematical methods and discrete mathematics, areas introduced in 1985-86: age 9 (seven items), age 13 (five items), and age 17 (eight items).

A Rescue Plan for the NAEP Long-Term Trend Assessments: Thoughts on Edward Haertel's White Paper

Prepared for the National Assessment Governing Board

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February 2017

SUMMARY: In order to rescue the Long-Term Trend (LTT) assessments from failure, three activities will soon be necessary. First, administrative procedures for the LTT assessments should be changed by (a) adapting the paper-based items into a form compatible with administration on a digital platform—the way it is being done for the rest of the NAEP assessments, (b) shifting the testing window for all three age groups to correspond to the rest of the NAEP assessments, and (c) planning to field test replacement cognitive exercises in the year prior to each LTT assessment. Second, a bridge study should be conducted within the next three years to connect the old and new procedures for conducting the LTT assessment. Third, the framework and item specifications for the LTT reading and mathematics assessments should be rewritten to assist the public in understanding what these assessments were intended to measure.

Ed Haertel's white paper addresses two issues central to the future of NAEP's LTT assessments. The first issue is whether the LTT assessment component of NAEP should be continued in essentially its current form, or dropped altogether. I agree with Haertel's conclusion that the LTT assessments should be continued, but modifications that maintain trend lines will be necessary. Continuation is a policy decision that I will leave to policy experts, to the people who balance budget priorities, and to the National Assessment Governing Board. I'm more of a technical expert and will direct my comments to technical concerns.

The 2004 redesign of the LTT assessments came about because the prior design, which has been in place since the mid-1980s, had become unworkable. Dropping the science and writing assessments left holes in the assessment instruments, and students with disabilities were not being provided accommodations. The 2004 redesign and its associated bridge study corrected this situation, but left some problems unresolved. After two more decades, in 2024, the 2004 design for the LTT assessments again needs attention, because by that time the design will have become unworkable. If it is not redesigned, I believe that it cannot succeed.

The second issue Haertel raised is the operational and administrative modifications that are needed to ensure efficient conduct of the LTT assessments. I agree with Haertel's proposal to gain operational economies by integrating their mode of administration, their sampling activities, their field operations, and their scoring activities. I also agree that moving from paper to digitally based assessment formats will take advantage of the economies of digital administration. It is not simply a matter of how the students take the assessment, but a matter of the entire survey operations infrastructure. Resource savings would derive from not having to maintain separate production facilities for paper test forms (printing, distribution, data collection, converting to digital data files, and scoring the constructed responses). Such an integration plan will require a bridge study, in which the current and revised field operations are both conducted in the same year, so that the trend lines can be shown to be continuous.

My belief is that the current plan for the next administration in 2024 of the LTT assessments will be too expensive to succeed. This assessment can be cancelled or postponed again on

relatively short notice, but without some significant changes to reduce costs, this assessment survey program cannot continue. If it is to survive, it must be rescued (hence my paper's title).

I want to raise a third issue, which Ed Haertel's white paper addresses only indirectly. That issue is how to remedy the inadequacies of the materials that serve in place of a content framework and item specifications for the LTT assessments. While Haertel was able to develop an understanding of the content of the reading and mathematics assessments, he found the process surprisingly difficult. It is also difficult for the public and for NAEP contractors whose job it is to develop replacement cognitive exercises to get a firm grasp on what the LTT assessments are intended to measure. In my opinion, remediation of the framework is also essential, but can be addressed on parallel track with the other administrative changes (and could take longer to implement).

The technical challenges in merging the cognitive assessment content of the main NAEP and LTT assessments are insurmountable. Irreconcilable differences exist between the LTT and main NAEP assessments. One difference is that the two assessments use incompatible exercise booklet formats (with three 15-minute versus two 30-minute blocks of cognitive exercises). Pairing LTT and main NAEP exercise blocks in the same booklets would result in administrative difficulties due to mismatched timing. While this design feature could be changed, other differences virtually eliminate the value of making such a change.

The LTT assessments are commonly understood to measure the basic skills that were considered important two generations ago, but Haertel showed in his white paper that this vague understanding is inadequate. The content and cognitive processes assessed by LTT exercises fall within and below the range of typical curricular expectations for grades 4, 8, and 12, but more advanced topics and more complex processes at these grade levels are largely omitted.

Another important difference is that the LTT assessments' age-based populations contain substantial minorities who are enrolled below the modal grade level. At each age group, there is a mixture of a majority of students at the typical grade (4, 8, and 11) and another substantial proportion below the modal grade level (in grades 3, 7, and 10). Among NAEP's 9- and 13-year-old populations, 37 percent were enrolled in grade 3, not grade 4, and 39 percent in grade 7, not grade 8. Among NAEP's 17-year-olds, 23 percent are enrolled in grade 10, not grade 11, and only a small proportion are enrolled in grade 12 (see Table 1). The LTT cognitive exercise pool is appropriate for the inclusion of a substantial minority of students below the modal grade level and does not include the advanced content that is important to main NAEP.

A corresponding difference exists for main NAEP's grade-based populations. Among fourth graders, a substantial proportion are 10 years old. Among eighth graders, a substantial proportion are 14 years old. And among 12th graders, a substantial fraction are 18 years old when assessed. Items that are grade-appropriate, or include more advanced content for main NAEP are likely to be too hard for the below-modal-grade proportion of the LTT's population.

Haertel concluded, and I agree, that the technical challenges in merging the cognitive content of the main NAEP and LTT assessments cannot be surmounted. The cognitive measurements and target populations of the two NAEP assessment programs are too different to be integrated

into a common, dual-purpose assessment. Haertel recommended, and I agree, that two operational aspects of the LTT assessment should be substantially revised: (a) the assessment should shift from paper-based to digitally based assessment forms; and (b) the testing window for all three age groups should be time-shifted to correspond to that used for the rest of the NAEP assessments. These changes would make possible the pilot testing of replacement cognitive exercises the year prior to each LTT assessment, rather than four years in advance.

Without the need to include main NAEP assessment blocks or items of reading and mathematics in the LTT (or vice versa), there is no need to move the schedule for the LTT assessments into the same years that the main NAEP reading and mathematics assessments are administered.

The LTT assessments should stop using paper forms and switch to digitally based assessment instruments, just as the rest of NAEP is doing. Future resources can be conserved by redesigning these assessments to conform their administrative procedures to those of other NAEP assessments, while maintaining the defining content differences between reading and mathematics in main NAEP and in the LTT assessments.

I foresee an administrative obstacle to the current assessment schedule in which the next LTT is administered in 2024 on paper forms. The bulk of the transition to digital administration for the most of NAEP's assessments is scheduled to be completed by in 2019, with relatively small national-only assessments scheduled for 2020 and beyond. The NAEP project's capacity to handle paper-based assessment forms may have been lost several years before the next scheduled administration of the LTT assessments in 2024. It will be hard to justify the expense of maintaining or recovering NAEP's capacity to handle paper-based administration for the relatively small, national-only samples of the LTT.

The staff and contractors for the main NAEP assessments have gained substantial experience when switching from paper-based to digitally based assessment formats. The LTT assessments can take advantage of this experience. Since the vast majority of cognitive exercises in the LTT assessments are multiple-choice, the trans-adaptation of the items onto a digital platform should not be problematic. Instituting such changes will nevertheless require an initial investment in delivery software and converting the existing item pool into digital formats.

I do not foresee difficulties with moving to computer-based administration. However, it does take a certain amount of lead time to translate the paper-based items into a form suitable for administration on a digital platform and to develop the software needed to administer the items.

The LTT assessments should shift the time of year during which they are conducted in order to share organizational capacities with other NAEP assessments. Moving to a common testing window—the period from late January to early March—would provide for integrated sampling and data collection procedures. The savings would derive from not having separate sampling operations, school recruitment, staff training activities, field staff, scoring operations, and the management activities to oversee them over the longer period.

Haertel noticed that changing the time of year of administration will change the average age of the students being assessed and proposed that the date ranges that define age should be

changed as well, in order to maintain the same average age of the student populations. Table 1 presents the current date ranges that define ages 9, 13, and 17 for the purpose of determining whether students are part of NAEP's three age-based populations, along with the dates during which NAEP conducts the LTT assessments. Subtracting the midpoints of the two date ranges provides an estimate of the average age at the time of testing for the three age groups. The NAEP Data Explorer provides estimates of the proportion of 9-, 13-, and 17-year-old students in 2012 who were enrolled below the modal grade level. Each age group has substantial proportions of students below the modal grade level and small proportions (not shown in Table 1) who are enrolled above the modal grade level.

However, Haertel overlooked another consequence of changing the date ranges, and that is that the proportion of students below the modal grade level would also change. Schools have fixed cutoff dates for enrolling students when they start school. Changing NAEP's date ranges would shift more or fewer students across the local age-of-school-entry boundaries.

I did some investigation into what the effect might be. The Census Bureau publishes annual tables of single grade enrollments by single years of age based on the Current Population Survey October school supplement. I used these tables to estimate the proportion of 9-, 13-, and 17-year-old students who are enrolled below the modal grade level, which depends on whether the defining age range is changed by three months (as Haertel recommended), by one month, or not at all. These results are shown in Table 2.

Using the current age-defining date ranges, I was able to project the proportion of students who are below grade level for each age group and match within a couple of percentage points the actual proportions below grade level that were reported in the most recent LTT online data in Table 1. Haertel noticed that if the LTT assessment were to be administered during the main NAEP data collection window, the 13-year-old students would be three months older than they would have been during the fall testing window. Haertel proposed shifting the defining date range for these students later by three months in order to maintain the same average age. My projection (in Table 2) indicates that this change would result in a decrease of the proportion enrolled below the eighth grade from 41 percent to 30 percent. This decrease could have just as much impact, in the opposing direction, as the change in scores attributable to being in school for three months longer. Consequently, I recommend not changing the current date ranges that define age for the 13-year-olds.

Haertel also noticed that if the LTT assessment were to be administered during the main NAEP data collection window, the 17-year-old students would be three months younger than they would have been under the current testing window. In fact, the average age of "17-year-olds" at the new time of assessment would fall to from just over 17 to just under (16.9 years old). He proposed shifting the defining date range for these students earlier by three months in order to maintain the same average age. My projection indicates that this change would result in an increase in the proportion enrolled below the 11th grade from 24 percent to 30 percent. This increase could have just as much impact, in the opposing direction, as the change in scores attributable to attending school three months less.

However, a case could be made that the average age at assessment for a population of "17-year-olds" should be at least 17.0 years. Changing the defining date range by one month (rather than Haertel's suggested three months) would bring the average age above 17.0 years and raise the projected proportion enrolled below 11th grade from 24 to 26 percent. In my opinion, accepting a small increase in the proportion below modal grade might be a price worth paying to keep the average age at assessment over 17 years.

The development and pilot testing of replacement cognitive exercises also deserves attention. The Governing Board has a policy of releasing NAEP assessment items. One reason for the 2004 revision of the design for the LTT assessments was to make possible the release and replacement of old cognitive items, in order to inform the public about the nature of the NAEP LTT assessments. No cognitive exercises had been released from these assessments since the Educational Testing Service (ETS) took over the contract from Education Commission of the States (ECS) in 1983. Between 1984 and 1999, no replacement items were developed. Over these years, the craft of writing items to meet the LTT objectives was not passed along to the next generation of item writers, and the institutional memory at ECS about assessment objectives was lost. The content objectives have not been revisited in three decades, and the committees that set the objectives were disbanded long ago.

When in 2001-02, ETS began for the first time to develop replacement cognitive exercises for the 2004 assessment, the item development staff at ETS were unfamiliar with the objectives of LTT assessments. Lacking a content framework and item specifications, the staff created their own item specifications based on the existing item pool in place in 1999. The ETS item writing staff have tried to mimic very closely the features of items that are being released (and those in the item pool), rather than write new items to meet the old lists of objectives.

The existing main NAEP standing committees for reading and mathematics have subcommittees that review the items for the item development contractors as they are being created. However, these content experts are much more familiar with main NAEP frameworks and specifications than with the lists of objectives that are supposed to underlie the content of the LTT assessments. Because the materials that define the intended content of the LTT assessments are inadequate, this group of experts is not able to provide guidance on the adequacy of the coverage of the framework with the current set of items, and any holes that might need to be filled with replacement items.

New items were expected to be field-tested on the same age-based sample as the operational LTT assessment. This required such items to be ready four years in advance of the next administration. Allowing time for development means that staff needed to be working to develop replacement items at least five or six years ahead of their use. Integrating the sampling procedures with the main NAEP testing window will make it easier to integrate the field testing of replacement exercises with other NAEP assessments. Such a change would make possible a much shorter lead time for item development and a shorter interval between field testing and operational administration of the LTT assessments.

A bridge study is necessary to connect the old and the new administrative procedures. Haertel proposed conducting a bridge study in which the LTT assessment is administered twice, once in digital form and again with paper assessment forms. The two administrations would be linked either through a common population or through common items in the same year (or both). Comparison of the results of the two assessments would be able to demonstrate that the trend lines can (or cannot) be preserved. Continuity with past assessments would be ensured by linking to the paper version, and continuity with future administrations ensured by linking to the digital version.

Bridge studies like this are being conducted during the years 2015–2019 in other NAEP subjects, in order to maintain trend lines across modes of administration (ETS, 2015). By the time such a bridge study would need to be conducted for the LTT assessment, NAEP will have had a great deal of institutional experience with bridge studies that link digital and paper forms of the assessment.

The LTT bridge study needs to be conducted before the capacity to handle paper-based administration disappears from NAEP. This means that the currently scheduled 2024 LTT assessment, if it were to be administered digitally, would have to be preceded by a bridge study conducted several years earlier, before NAEP's paper-handling capacity is lost. I recommend that the Governing Board conduct the bridge study for the LTT assessment in 2020, and return to the four-year interval between administrations of the NAEP LTT assessments in 2024.

Each condition in a bridge study requires funding, and the combination of both would require more resources than simply re-administering the current paper-based design in its three testing windows. It is as if NAEP were to administer two LTT assessments in reading and mathematics at once (one on paper booklets and one on a digital platform).

Haertel proposed having a third experimental condition to distinguish the effects of moving from paper to digital administration from the effects of moving the time of year of the assessment. I think the extra resources required to have a third condition would not be worth the costs. Unless it would be possible to implement only one of the two administrative procedures, there is no need to know the separate effects of the two changes. But both of these changes are necessary to keep the costs of the LTT assessments under control. It would not be feasible to implement only one of them.

The objectives booklets that define content coverage for the LTT assessments are insufficient to explain what is intended to be measured. Haertel found it surprisingly difficult to clarify just what the LTT assessments measure. No explicit content frameworks exist for the LTT assessments. The topics that these assessments should cover are defined instead by booklets of objectives that provide much less detail than any current NAEP content framework. Main NAEP provides item specifications for the item writing staff, but no such item specifications exist for the LTT assessments.

The objectives booklets for reading and mathematics changed over time. During the first four cycles of reading and mathematics assessments, the lists of objectives changed with each administration. Because ECS thought that NAEP should provide a model of excellent cognitive

exercises to the field of education, about half of the cognitive exercises and reading passages were released each time. The pool of common items shrunk during NAEP's first decade, until the test booklets were frozen.

The trend lines that now constitute the LTT assessments emerged from the reading and mathematics scales developed by ETS when it took over the NAEP project in the early 1980s. The cognitive exercise pool during the frozen period are those items that survived screening on technical criteria, screening for bias, and screening for outdated or obsolete content. As a result, the item pool does not fully reflect the intended final list of objectives. It is quite likely that the existing item pool does not even fully cover the final set of NAEP objectives.

I have included an appendix containing references to published materials from the early days of NAEP. This includes all nine objectives booklets for reading and mathematics and released items from those early ECS years. Nearly all such materials are available from the Educational Resources Information Center, in printed form or downloadable as scanned documents.

A concerted effort is needed to clarify what the LTT assessments measure in reading and mathematics. A rewritten framework and item specifications would assist the pubic in understanding what it is that the LTT assessments were intended to measure. These materials would also be invaluable in developing cognitive exercises that not only replace released items, but also fill in gaps in intended content coverage that has long been missing.

In the decades since the transition from ECS to ETS, the standards for what constitutes an adequate content framework and item specifications have changed, and the NAEP authorization law assigned the responsibility for developing frameworks to the National Assessment Governing Board. The old objectives booklets are no longer sufficient guidance for developing replacement items. A rewritten framework and item specifications are needed to develop and field test cognitive exercises that can replace exercises as they are released.

I believe that the National Assessment Governing Board is the institution best suited to conduct the activities needed to retrofit an updated framework and item specifications onto the LTT reading and mathematics assessments. Currently, the Governing Board decides on the frameworks for main NAEP, and re-evaluates and makes changes in these frameworks from time to time. The law does not address the Board's responsibility with respect to the content of the LTT assessments, but it assigns duties that can be understood to apply to this aspect of the LTT as well as main NAEP assessments.

I read NAEP's authorizing legislation again, to see who was assigned the responsibility to oversee the content of the LTT assessments. I found that The National Assessment of Educational Progress Authorization Act (P.L. 107-279) does not prohibit the Governing Board from taking on this responsibility for the LTT assessments. Under 20 USC 9621, Section 302(e)(1) paragraph (C) the "Assessment Board" has been given the duty to "develop assessment objectives consistent with the requirements of this section and test specifications that produce an assessment that is valid and reliable." Paragraph (F) of this section implies that this duty pertains to the main NAEP assessments in grades 4, 8, and 12, but does not specifically mention this duty with respect to the LTT assessments for ages 9, 13, and 17. Paragraph (I) of the same section

assigns to the Board the duty to take action to improve the content of the NAEP assessments, not distinguishing between the main and the LTT assessments.

I found that the part of the law that *does* address the LTT assessments [20 USC 9622, Section 303(a)], assigns the responsibility for these assessments to the Commissioner of Education Statistics (with advice from the Assessment Board), but makes no mention of "assessment objectives" or "test specifications." However, NCES does not have experience with managing committees to originate or re-evaluate content frameworks. The National Assessment Governing Board does have considerable experience with such activities and should more appropriately take on this role.

From the existing objectives documents and item pools that are currently, or have been included in the item response theory (IRT) reading and mathematics scales, the Governing Board ought to be able to develop framework and specifications documents that would provide a blueprint for developing replacement reading and mathematics exercises for future administrations of the LTT assessments. The goal of such a project would be not to develop a new framework or to make such changes in the framework that would cause a break in trend, but to make explicit the frameworks and item specifications of this existing assessment survey program. Developing a retrofitted framework and item specifications that conforms as closely as possible to the intentions of the old objectives and the existing item pool may take several years, but in my opinion, this is an essential activity if the LTT assessments are to be preserved.

While creating a framework and item specifications for reading and mathematics are essential to the long-run health of the LTT assessments, such activities are not likely to be completed within three years. Since there already exists a supply of replacement items that can be used in a 2020 bridge study, completing the framework updating activity is not necessary prior to undertaking a LTT bridge study.

Summary of what needs to be done to rescue the LTT assessments. In order to rescue the LTT assessments from failure, three activities will soon be necessary:

1. Changing the administrative procedures for the LTT assessments by (a) moving the paper-based LTT cognitive exercises and reading passages onto a digital platform for administration the way it is being done for the rest of NAEP assessments, (b) shifting the testing window for all three age groups to correspond to the testing window for the rest of the NAEP assessments, and (c) planning to field test replacement cognitive exercises in the year prior to each LTT assessment.
2. Conducting a bridge study in 2020 to connect the old and new LTT lines.
3. Rewriting/retrofitting the framework and item specifications for the LTT reading and mathematics assessments to assist the pubic in understanding what it is that these assessments were intended to measure.

References

Educational Testing Service (2015). *NAEP's Transition to Digitally Based Assessment*. White paper prepared for the National Center for Education Statistics.

Table 1: Testing windows, age midpoints, and modal grade, by age group and various age definitions: NAEP 2012 Long-Term Trend assessments

	LTT assessment windows and LTT birthdate ranges		
	Age 9	Age 13	Age 17
Date range of assessment window	January 2, 2012 to March 9, 2012	October 10, 2011 to December 16, 2011	March 12, 2012 to May 11, 2012
Midpoint of assessment period	2/4/2012	11/12/2011	4/11/2012
Date range of birth year	January 1, 2002 to December 31, 2002	January 1, 1998 to December 31, 1998	October 1, 1994 to September 30, 1995
Midpoint of birth year	7/2/2002	7/2/1998	4/1/1995
Age at assessment	9.6	13.37	17.04
Percent below modal grade	37	39	23

SOURCE: U.S. Department of Education, National Assessment of Educational Progress (NAEP), 2012 Long-Term Trend Reading Assessments.

Table 2: Birth year midpoints, main NAEP assessment period, and projected age at assessment and modal grade, by age group and three birthdate ranges: NAEP 2012 Long-Term Trend assessments

		3-month change in birthdates	1-month change in birthdates	No change in birthdate range
9	Midpoint of birth year	—	—	7/2/2002
	Midpoint of assessment period	—	—	2/15/2012
	Average age at assessment	—	—	9.6
	Projected percent below modal grade	—	—	40
13	Midpoint of birth year	10/2/1998	8/2/1998	7/2/1998
	Midpoint of assessment period	2/15/2012	2/15/2012	2/15/2012
	Average age at assessment	13.4	13.5	13.6
	Projected percent below modal grade	30	35	41
17	Midpoint of birth year	12/31/1994	2/28/1995	4/1/1995
	Midpoint of assessment period	2/15/2012	2/15/2012	2/15/2012
	Average age at assessment	17.1	17.0	16.9
	Projected percent below modal grade	30	26	24

SOURCE: U.S. Census Bureau, Current Population Survey, October supplement 2011 (Table 2: Single years of enrollment by single years of age).

Appendix

EARLY NAEP PUBLICATIONS

Some early NAEP materials describing the content of what became the LTT mathematics and reading assessments are available from the Educational Resources Information Center (ERIC) in microfiche or hard copy, or downloadable as scanned documents. ED numbers are provided, enabling the user to consult any of approximately 600 libraries and ERIC clearinghouses and depositories around the United States, including the ED library in FB6, or to download electronic versions of the documents.

The term "technical report" as used in the early days of NAEP does not correspond to current usage in NAEP. They were published in several volumes. It appears that some volumes contained further tabulations of results and others may have contained sets of released items. The "exercise volumes" are fat documents that contain detailed pages of tabulations (text of an item, followed by performance on that item by various population subgroups).

ETS maintains a computerized database containing information about every item used by NAEP during its 30-year history—all of the descriptive, processing, and usage information on every NAEP item since 1969. More than a decade ago, ETS created a unified database that incorporated the item database received from Education Commission of the States (ECS) with its own database of items.

Early Methodological Publications

SY-ED-70 *The National Assessment Approach to Exercise Development*. A technical booklet outlining the early days of developing exercises, 1970.
ED 067 402 .....

12-IP-55 *The National Assessment Approach to Objectives and Exercise Development*. A policy paper describing methods for developing objectives and test specifications, writing and testing items, structuring test booklets, and scoring items. By Barbara Ward, 1980.
[NCES has a copy].....

432 *Stability of the National Assessment Scoring Methods*, by Nancy W. Burton. An article published in the Summer 1980 issue of *Journal of Educational Measurement*
.....

SY-OI-36 *A Guide to National Assessment Objectives and Items*. An 8-page folder explaining what NAEP has produced in the way of objectives and exercises or items in the various learning areas. .....

Early Mathematics Publications

The earliest mathematics assessments included in the ETS trend lines (1978-79) were administered using paced audio tapes to assure uniform assessment conditions. A bridge study without the paced tape was conducted in 1985-86 for the mathematics/science trend assessments. Since the impact on science was large, the paced tape was retained until the science assessment was dropped after 1999. In the early years, half the assessment items were released for use by the public after each administration.

Technical Materials:

04-MA-20 *Mathematics Technical Report: Exercise Volume*. 1,412 pp. (marginal legibility of original document). Appendix A discusses the mathematics objectives measured by the exercises; Appendix B outlines the 15 mathematics content areas covered by the assessment; Appendix C lists the released mathematics exercises; and Appendix D provides information about the unreleased items. 1977.
ED 138 468 .....

09-MA-40 *Procedural Handbook: 1977-78 Mathematics Assessment*. A description of NAEP's procedures for objectives redevelopment through data collection and analysis to reporting the results, 1980.
ED 186 280 .....

13-MCS-40 *Procedural Handbook: 1981-82 Mathematics and Citizenship/Social Studies Assessments*. A description of NAEP's procedures for development of objectives and exercises, sampling, data collection, scoring, analysis, reporting, etc., 1983, 125 pages
.....

Johnson, Eugene. (1988). Chapter 10.2, Mathematics Data Analysis: Scaling of the Trend Data. Pp. 236–240 in Albert E. Beaton (ed.), *Expanding the New Design: The NAEP 1985–86 Technical Report* (No. 17-TR-20). Princeton, NJ: Educational Testing Service.
This chapter of the second ETS-authored NAEP technical report describes the procedures used to create a unidimensional IRT scale for what became the LTT mathematics scale.
ED 355 248 .....

Objectives:

Mathematics Objectives. A 41-page booklet describing the objectives used for exercises administered in the first mathematics assessment, 1970.
ED 063 140 .....

09-MA-10 *Mathematics Objectives, Second Assessment*. A 56-page booklet describing the objectives upon which the second assessment exercises were based, the procedures used for developing them and the persons involved in the process, 1978.
ED 156 439 .....

13-MA-10 *Mathematics Objectives, 1981-82 Assessment*. A 48-page booklet describing the evolution of math objectives for three different assessments, and the persons involved in formulating them, 1981.
ED 211 352 .....

17-M-10 *Math Objectives, 1985-86 Assessment*. A 26-page booklet offering background on previous math assessments and setting forth the development process and framework for the 1985-86 assessment, 1986
ED 273 682 [NCES has a copy] .....

Mathematics Objectives, 1990 Assessment. A booklet describing the development process and framework for the 1990 assessment, 1988
ED 309 030 [NCES has a copy] .....

Released Exercises:

Selected Supplemental Mathematics Exercises. Information on the contents, 1977.
ED 183 388 .....

09-MA-25 *The Second Assessment of Mathematics, 1977-78, Released Exercise Set*.
A 362-page loose-leaf set with national results for attitudinal items and national and selected group results for cognitive items. Contains 252 exercises. Suitable for reproduction. Objectives booklet included, 1979. (marginal legibility of original document)
ED 187 543 .....

13-MA-25 *The Third Assessment of Mathematics, 1981-82, Released Exercise Set.* A 287-page set with national results for attitudinal items, and national and modal grade results for cognitive items. Loose-leaf format suitable for reproduction. Objectives booklet included, 1983
.....

Early Reading Publications

The three earliest reading assessments (1970-71, 1974-75, and 1979-80) were administered using paced audio tapes to assure uniform assessment conditions. The paced tape method was dropped after 1983-84 for the reading/writing LTT, but not for mathematics/science trend assessments. In the early years, half the assessment items were released for use by the public after each administration.

Technical Materials:

11-RL-40 *Procedural Handbook: 1979-80 Reading and Literature Assessment*. A thorough description of the methods used in this assessment: redevelopment of objectives, formulation of exercises, sampling, data collection, scoring, analysis and reporting, 1981.
ED 210 300 .....

Mislevy, Robert, and Sheehan, Kathleen. (1987). Chapter 10.4, Trend Analysis. Pp. 361-390 in Albert E. Beaton (ed.), *Implementing the New Design: The NAEP 1983–84 Technical Report* (No. 15-TR-20). Princeton, NJ: Educational Testing Service. This chapter of the first ETS-authored NAEP technical report describes the procedures used to create a unidimensional IRT scale for what became the LTT reading scale.
ED 288 887 .....

Objectives:

02-R-10 *Reading Objectives*. A 34-page booklet describing the objectives used for exercises administered in the first reading assessment, 1970.
ED 041 010 [NCES has a copy] .....

06-R-10 *Reading Objectives, Second Assessment*. A 21-page booklet describing the objectives used for exercises administered in the second reading assessment, 1974.
ED 089 238 .....

11-RL-10 *Reading and Literature Objectives, 1979-80 Assessment*. A 28-page booklet describing the integrated objectives used for exercises administered in the third reading and second literature assessment, 1980.
ED 185 503 .....

15-RL-10 *Reading Objectives, 1983-84*. This booklet describes the objectives used for the fourth reading assessment, 1985
ED 243 086 .....

17/19-R-10 *Reading Objectives, 1986 and 1988 Assessments.* This booklet presents the reading objectives for the fifth and sixth assessments, 1987.
ED 287 876 [NCES has a copy] .....

Reading Objectives, 1990 Assessment. A booklet describing the development process and framework for the 1990 reading assessment, 1989
ED 307 598 [NCES has a copy] .....

Released Exercises:

02-R-20 *Reading: Released Exercises*, 1973, 424 pp.
ED 079 684 .....

02-R-25 *The First Assessment of Reading, 1970-71 Assessment, Released Exercise Set*, 1979. 341 pp.
ED 191 017 .....

11-RL-25 *Reading/Literature Released Exercise Set, 1979-80 Assessment*, April 1981. A loose-leaf set of 82 released exercises with documentation, national results and scoring guides. Suitable for reproduction, objectives booklet included. 351 pp.
ED 205 588 .....

11-RL-26 *Reading/Literature Released Exercise Set, 1979-80 Assessment, Supplement*, April 1981. Provides sample written responses to open-ended questions. 471 pp.
ED 205 589 .....